

*\*XX. Experiments for ascertaining the Point of Mercurial Congelation. By Mr. Thomas Hutchins, Governor of Albany Fort, in Hudson's Bay †.*

Read April 10, 1783.

THE following experiments, to determine the freezing point of quicksilver, were made by the direction of the Royal Society, at Albany Fort in Hudson's Bay, situated in the latitude of  $52^{\circ} 14'$  North and  $82^{\circ}$  West longitude from Greenwich.

The instruments used in these experiments were simply thermometers, except the apparatus F and G, furnished by Mr. CAVENDISH, and of these a more satisfactory idea will be formed from the annexed drawing than could be conveyed by words alone; I have, therefore, only specified a few particulars, so that each instrument may be distinguished from another.

I have compared the instruments with each other for several weeks in the various temperatures, to adjust, with the greater precision, the relative degrees on the scales; which was the more necessary as they differed very much.

The five first experiments were made exactly according to the directions sent to me by the Society, in order to obtain the point of congelation. The two succeeding ones are also made in the manner they directed, to endeavour to ascertain the greatest degree of contraction mercury is capable of; then follow two

† This paper having been for some time mislaid, could not be printed in its turn. This accounts for the double paging and signatures.

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\*S f

experiments



experiments made in a different manner by my own suggestion; and, lastly, an account of mercury frozen in the open air without the aid of any artificial cold, which will be found to corroborate the preceding experiments, and determine the exact point of congelation to be at  $40^{\circ}$  below the cypher. I have been careful to mark down every circumstance attending the experiments, and have added a few observations to each of them, to elucidate any uncommon phænomena that occurred.

If these experiments should be agreeable to the Royal Society, the merit must be attributed to the excellent instructions they transmitted to me, which left me nothing to do but to follow them; yet I cannot avoid doing justice to the ingenious Dr. BLACK, Professor of Chemistry at Edinburgh, who favoured me with some remarks on the experiments I made in 1775 to freeze quicksilver, and first suggested this method of ascertaining the point of congelation, which I had the honour of communicating to the Royal Society by the means of SAMUEL WEGG, esq. whose attention to promote the views of the Society can only be equalled by that liberality of sentiment and great goodness of heart which makes him encourage even the most feeble attempt than can in the least tend to the improvement of knowledge.

THOMAS HUTCHINS.

*Dr.*



*Dr. BLACK's Letter referred to above.*

DEAR SIR,

Edinburgh, 5th Oct. 1779.

I HAVE read with great pleasure the experiments made at Hudson's Bay, upon the congelation of mercury, and observe that the author has succeeded perfectly in effecting it; but could not determine with precision what degree of cold was necessary to produce it. This, however, does not surprize me, as I have always thought it evident, from Professor BRAUN's experiments, that this degree of cold cannot be discovered conveniently by congealing the mercury of the thermometer itself. I shall not here give my reasons for this opinion; they would lengthen out this letter too much; I shall only propose what appears to me the proper manner of making the experiment, which is as follows: provide a few wide and short tubes of thin glass, sealed at one end and open at the other; the wideness of these tubes may be from half to three-quarters of an inch, and the length of them about three inches. Put an inch or an inch and an half depth of mercury into one of these tubes, and plunging the bulb of the thermometer into the mercury, *set the tube with the mercury and the thermometer in it* into a freezing mixture, which should be made for this purpose in a common tumbler or water-glass; and, N. B. in making a freezing mixture with snow and spirit of nitre, the quantity of the acid should never be so great as to dissolve the whole of the snow, but only enough to reduce it to the consistence of Pannada. When the mercury in the wide tube is thus set in the freezing mixture, it (the mercury) must be stirred gently and



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frequently with the bulb of the thermometer ; and if the cold  
be sufficiently strong, it will begin to congeal by coming thick  
and broafy like an amalgam. As foon as this is obferved, the  
thermometer fhould be examined without lifting it out of the  
congealing mercury ; and I have no doubt, that in every expe-  
riment, thus made, with the fame mercury, the inftrument will  
always point to the fame degree, provided it has been made  
and graduated with accuracy.

I am, DEAR SIR,

Your faithful humble fervant,

JOSEPH BLACK.

To Mr. ANDREW GRAHAM, Edinburgh.



*Thermometers described,*

- A. Represents a mercurial thermometer, with an air-bulb at the top, graduated 628 degrees below the cypher, and marked at every second degree. Makers NAIRNE and BLOUNT; the scale box-wood.
- B. Another mercurial thermometer graduated to 526° below the cypher, each line representing 2°, made by NAIRNE and BLOUNT; the scale box-wood.
- C. Is a fine mercurial thermometer, with an air-bulb at the top graduated 2300° below the cypher, each division containing 5°; the scale made of box, by THROUGHTON.
- D. A small spirit thermometer on a box scale, made by THROUGHTON, and divided to every single degree down to 160° below the cypher.
- E. Another spirit thermometer, by the same maker (THROUGHTON) graduated 90° below the cypher; the scale box.
- F. A small mercurial thermometer, on an ivory scale, divided at every 5° between 220° above and 250° below the cypher; made by NAIRNE and BLOUNT.
- G. Another mercurial thermometer, every way like the last mentioned, except only reaching from 215° above to 250° below the cypher; by NAIRNE and BLOUNT.
- H. A spirit thermometer, made by NAIRNE and BLOUNT, with which I have made meteorological observations from the year 1774.



Thermometers compared.

Year, Month, and Day.	Hours.	A.	B.	C.	D.	E.	F.	G.	H.	
1781										
Nov. 23	10 AM	+ 2 $\frac{1}{2}$	+ 5	+ 7	+ 9	+ 8	+ 7	+ 7 $\frac{1}{2}$		
24	10 AM	- 7	- 4	- 1	+ 2 $\frac{1}{2}$	+ 2	0	+ 1		
	Noon	+ 2	+ 4	+ 7	+ 9	+ 8 $\frac{1}{2}$	+ 8	+ 8 $\frac{1}{2}$		
25	10 AM.	- 4	- 1	+ 1 $\frac{1}{2}$	+ 4	+ 3 $\frac{1}{2}$	+ 2	+ 2		
	3 PM.	+ 11	+ 13 $\frac{3}{4}$	+ 15	+ 16 $\frac{1}{2}$	+ 15	+ 15	+ 15 $\frac{1}{2}$		
26	10 AM.	+ 4 $\frac{1}{2}$	+ 7	+ 8	+ 10	+ 9	+ 7 $\frac{1}{2}$	+ 8		
27	10 AM.	0	+ 2 $\frac{1}{2}$	+ 5 $\frac{1}{2}$	+ 7	+ 6 $\frac{1}{2}$	+ 5	+ 5 $\frac{1}{2}$		
	5 PM.	+ 4 $\frac{1}{2}$	+ 7	+ 9	+ 11	+ 10	+ 9 $\frac{1}{2}$	+ 10		
28	10 AM	- 9 $\frac{1}{2}$	- 6	- 2 $\frac{1}{2}$	+ 2	+ 1 $\frac{1}{2}$	+ 2	+ 2 $\frac{1}{2}$		
29	10 AM.	- 3	+ $\frac{1}{2}$	+ 4 $\frac{1}{2}$	+ 6 $\frac{1}{2}$	+ 3 $\frac{1}{2}$	+ 3	+ 3		
30	10 PM	+ 11	+ 14	+ 15 $\frac{1}{2}$	+ 16	+ 15 $\frac{1}{2}$	+ 15	+ 15 $\frac{1}{2}$		
Dec. 1	10 AM.	+ 17 $\frac{1}{2}$	+ 20	+ 22 $\frac{1}{2}$	+ 21 $\frac{1}{2}$	+ 21	+ 21	+ 22		
	11 AM.	+ 23	+ 25 $\frac{1}{2}$	+ 27	+ 26 $\frac{1}{2}$	+ 26	+ 27	+ 27		
	10 AM.	+ 27 $\frac{1}{2}$	+ 29 $\frac{1}{2}$	+ 30 $\frac{1}{2}$	+ 30	+ 29	+ 30	+ 30		
	10 AM.	+ 18 $\frac{1}{2}$	+ 20 $\frac{1}{2}$	+ 23	+ 22	+ 21	+ 21 $\frac{1}{2}$	+ 21		
	10 AM.	+ 25	+ 26 $\frac{1}{2}$	+ 27	+ 27	+ 26	+ 26 $\frac{1}{2}$	+ 27		
	10 AM.	+ 16	+ 18	+ 21 $\frac{1}{2}$	+ 21	+ 20	+ 20	+ 19		
	9 AM.	- 5	- 2 $\frac{1}{2}$	0	+ 3	+ 2 $\frac{1}{2}$	0 $\frac{1}{2}$	0		
15	8 AM.	- 24 $\frac{1}{2}$	- 22	- 20	- 13 $\frac{1}{2}$	- 14	- 20	- 19 $\frac{1}{2}$		
	Noon	- 23 $\frac{1}{2}$	- 20 $\frac{1}{2}$	- 18 $\frac{1}{2}$	- 12	- 13	- 20	- 20		
16	8 AM.	- 35	- 34	- 31	- 22 $\frac{1}{2}$	- 23	- 31 $\frac{1}{2}$	- 31		
1782										
Jan. 7	8 AM.	- 39 $\frac{1}{2}$	- 36 $\frac{1}{2}$	- 35	- 25	- 25	- 31 $\frac{1}{2}$	- 34		
	4 PM.	- 32	- 30	- 31	- 18	- 20	- 26	- 26	- 32	
	8 PM.	- 34	- 32	- 32	- 23	- 24	- 32	- 32	- 34	
12	8 AM.	- 44	- 42	- 40	- 29	- 29 $\frac{1}{2}$	- 40	- 39	- 42	
	Noon	- 36	- 34	- 32	- 21 $\frac{1}{2}$	- 22 $\frac{1}{2}$	- 33	- 32	- 37	
	4 PM.	- 28 $\frac{1}{2}$	- 26	- 25	- 16 $\frac{1}{2}$	- 17	- 25	- 25	- 30	
	8 PM.	- 14	- 12	- 10	- 5	- 5 $\frac{1}{2}$	- 11	- 10	- 16	
13	8 PM.	- 19	- 18	- 15	- 8	- 9	- 15	- 15	- 20	
14	8 AM.	- 24	- 21	- 20	- 13	- 13 $\frac{1}{2}$	- 20	- 20	- 24	
	Noon	- 22 $\frac{1}{2}$	- 20 $\frac{1}{2}$	- 18	- 11 $\frac{1}{2}$	- 12	- 19	- 19	- 23	
	4 P.M.	- 24	- 22	- 20	- 13	- 14	- 21	- 21	- 25	
	8 P.M.	- 30	- 28	- 26	- 17	- 18	- 23	- 23	- 30	
15	8 AM	- 38	- 36	- 35	- 24	- 24 $\frac{1}{2}$	- 36	- 36	- 37	
	Noon	- 32	- 30	- 27	- 18 $\frac{1}{2}$	- 19 $\frac{1}{2}$	- 26	- 26	- 33	
	4 P.M.	- 25	- 23	- 21	- 14	- 15	- 24	- 23	- 27	



Thermometers compared.

Year, Month, and Day.	Hours.	A.	B.	C.	D.	E.	F.	G.	H.	
1782										
Jan. 16	8 AM.	-17	-16	-12	-7	-8	-14 $\frac{1}{2}$	-15	-20	
	Noon	-7	-5	-4	+1	-0	-4	-4	-11	
	4 PM.	-6	-6	-5	-0	-1	-6	-6	-11	
17	8 AM.	-14	-12	-11	-4	-5	-9	-9	-16	
	Noon	-6	-4	-2	+2	+1 $\frac{1}{2}$	-3	-3	-10	
	4 PM.	+2	+4	+6	+8 $\frac{1}{2}$	+7 $\frac{1}{2}$	+5	+5	-2	
	8 PM.	-4	+2	-1	+4	+3	-1	-1	-5	
18	8 AM.	-9	-8 $\frac{1}{2}$	-5	-0	-1	-6	-6	-11	
	Noon	-2	-0	+2	+4	+4	-0	-0	-6	
	4 PM.	-8	-7	-5	-1	-2	-6	-6	-10	
	8 PM.	-15	-13	-11	-5	-6	-11	-11	-16	
19	8 AM.	-12	-10	-7 $\frac{1}{2}$	-4	-4	-9	-9	-14	
	Noon	-8	-6	-4	-0	-1	-5	-5	-12	
	4 PM.	-11	-10	-7	-3	-4	-8	-8	-12	
	8 PM.	-20	-18	-15	-9	-8	-11	-11	-20	
20	8 AM.	-12	-10	-7	-3	-3	-8 $\frac{1}{2}$	-8 $\frac{1}{8}$	-13	
	Noon	-12	-10	-7	-3	-4	-8	-8	-14	
	4 PM.	-16	-14	-12	-7	-6	-13	-13	-18	
	8 PM.	-21	-20	-17	-10 $\frac{1}{2}$	-11	-17	-17	-22	
21	8 AM.	-38	-36	-33	-24	-25	-38	-38	-37	
	Noon	-28	-26	-23	-16	-17	-25	-25	-30	
	4 PM.	-22	-20	-17	-12	-13	-18	-18	-24	
	8 PM.	-28	-26	-24	-16	-16 $\frac{1}{2}$	-24	-24	-28	Therm. C broke this day.
22	Noon	-19	-17		-8 $\frac{1}{2}$	-9	-15	-15	-21	
	4 PM.	-16	-14		-7	-8	-13	-13	-18	
	7 PM.	-20	-18		-9	-10	-17	-17	-22	
23	8 AM.	-34	-32		-21	-21 $\frac{1}{2}$	-30	-30	-34	
	Noon	-16	-14		-6 $\frac{1}{2}$	-7	-13	-13	-19	
	4 PM.	-12	-10		-4	-5	-9	-9	-14	
24	8 AM.	-14	-12		-4 $\frac{1}{2}$	-5	-10 $\frac{1}{2}$	-10	-16	
	Noon	-4	-2		+3 $\frac{1}{2}$	+3	-1	-1	-7	
	4 PM.	+2	-0		+5 $\frac{1}{2}$	+4	+2 $\frac{1}{2}$	+2	+4	
	8 PM.	-12	-10		-3 $\frac{1}{2}$	-4	-8	-8	-14	
25	8 AM.	-30	-28		-18	-18 $\frac{1}{2}$	-25 $\frac{1}{2}$	-25	-30	
	Noon	-30	-28		-17 $\frac{1}{2}$	-18 $\frac{1}{2}$	-25	-25	-30	



Thermometers compared.

Year, Month, and Day.	Hours.	A.	B.	D.	E.	F.	G.	H.	
1782									
Jan. 26	8 AM.	-103	-80	-33 $\frac{1}{2}$	-33	-42 $\frac{1}{2}$	-42	-46	{ Quick silver froze in air.
	9 AM.	-33	-44 $\frac{1}{4}$	-29	-29 $\frac{1}{2}$	-40	-40	-44	
	Noon	-34	-32	-21	-21 $\frac{1}{2}$	-30	-29 $\frac{1}{2}$	-34	
	4 PM.	-30	-28	-17	-18	-25	-25 $\frac{1}{2}$	-32	
	8 PM.	-38	-36	-24	-24	-35	-34	-36	
27	8 AM.	-44	-42	-29 $\frac{1}{2}$	-30	-40	-40	-43	Quick sil. not frozen.
	Noon	-28	-26	-16	-17	-24	-24	-28	
	4 PM.	-26	-24	-14	-14 $\frac{1}{2}$	-21	-21	-26	
	8 PM.	-30	-28	-17	-18	-25	-25	-29	
28	8 AM.	-30	-28	-17 $\frac{1}{2}$	-18	-25	-25	-30	
	Noon	-20	-18	-10 $\frac{1}{2}$	-11	-17	-17	-22	
	4 PM.	-22	-20	-12	-13	-18 $\frac{1}{2}$	-19	-23	
	8 PM.	-26	-24	-14	-14 $\frac{1}{2}$	-22 $\frac{1}{2}$	-23	-27	
29	8 AM.	-38	-36	-24	-24 $\frac{1}{2}$	-34	-34	-37	
	Noon	-32	-30	-19	-20	-27	-27	-32	
	4 PM.	-30	-28	-17	-18	-25	-25	-30	
30	Noon	-24	-22	-13	-14	-21	-21	-26	
	4 PM.	-26	-24	-14	-15	-20	-20	-26	
	8 PM.	-28	-26	-16	-16	-24	-23 $\frac{1}{2}$	-28	
31	8 AM.	-34	-32	-20	-21	-28	-28	-33	
	Noon	-24	-22	-13	-14	-20	-20	-26	
Feb. 1	8 AM.	-38	-36	-24	-24 $\frac{1}{2}$	-34 $\frac{1}{2}$	-35	-38	
	Noon	-28	-26	-16	-17	-25	-25	-9	
	4 PM.	-22	-20	-12	-13	-19	-19 $\frac{1}{2}$	-24	
2	8 AM.	-30	-26	-17	-18	-24 $\frac{1}{2}$	-25	-29	
	Noon	-20	-18	-9	-10	-15	-15 $\frac{1}{2}$	-21	
	4 PM.	-21	-19	-10	-10 $\frac{1}{2}$	-16	-16 $\frac{1}{2}$	-22	
	8 PM.	-22	-20	-10	-10 $\frac{1}{2}$	-16	-16 $\frac{1}{2}$	-22	
3	8 AM.	-18	-16	-9	-10	-15	-15	-20	
	1 PM.	-4	-2	+ 4	+ 3	-1	-1	-8	
	8 PM.	-13	-11	-4	-5	-8	-8	-14	
4	8 AM.	-12	-10	-3	-4	-7	-7	-12	
	Noon	-8	-6	-0	-0	-4	-4	-10	
5	8 AM.	-32	-30	-19	-20	-26 $\frac{1}{2}$	-27	-32	
	Noon	-16	-14	-6	-7	-13	-13	-18	
	4 PM.	-12	-10	-3	-4	-7	-7 $\frac{1}{2}$	-14	
	8 PM.	-12	-10	-2	-3	-7	-7	-14	



Thermometers compared.

Year, Month, and Day.	Hours.	A.	B.	D.	E.	F.	G.	H.	
1782									
Feb. 6	8 AM.	- 4	- 2	+ 3	+ 2	- 1	- 1	- 6	
7	8 AM.	-34	-32	-20	-21	-28	-28	-32	
	4 PM.	-14	-12	- 5	- 6	-10	-10 $\frac{1}{2}$	-16	
	8 PM.	-16	-14	- 6	- 7	-11	-11	-17	
8	8 AM.	-10	- 8	- 2	- 3	- 6	- 6 $\frac{1}{2}$	-12	
	Noon	-10	- 8	- 1	- 2	- 5 $\frac{1}{2}$	- 6	-12	
	8 PM.	-20	-18	- 9	-10	-14 $\frac{1}{2}$	-15	-20	
9	7 AM.	-24	-22	-14 $\frac{1}{2}$	-15	-20	-20 $\frac{1}{2}$	-26	
	Noon	-22	-20	-11	-12	-17 $\frac{1}{2}$	-18	-23	
	8 P.M.	-29	-26	-16	-17	-24	-25	-28	
10	8 AM.	-14	-12	- 3 $\frac{1}{2}$	- 4	- 9	- 9 $\frac{1}{2}$	-15	
	Noon	- 0	+ 2	+ 6	+ 5	+ 3	+ 2 $\frac{1}{2}$	- 4	
	4 PM.	+ 2	+ 4	+ 7	+ 7	+ 5	+ 5	+ 2	
	8 AM.	- 2	- 0	- 6	- 5 $\frac{1}{2}$	- 3	- 3	- 4	
11	8 AM.	-24	-22	-12	-13	-19	-19 $\frac{1}{2}$	-24	
	Noon	-18	-16	- 8	- 9	-14	-14 $\frac{1}{2}$	-19	
	4 PM.	-14	-12	- 5	- 5	-10	-10	-16	
	8 PM.	-24	-22	-12	-13	-19	-19 $\frac{1}{2}$	-24	
12	8 AM.	- 2	- 0	+ 5	+ 4	+ 1	- 0	- 5	
	Noon	+ 8	+10	+14	+13	+11	+10 $\frac{1}{2}$	+ 4	
	4 PM.	-10	-12	-16	-15	-14	-14	- 7	
	8 PM.	- 4	- 2	-10	-11	- 7	- 7	- 0	
13	8 AM.	-15	-12	- 4	- 5	-10	-10	-15	
	Noon	-12	-10	- 1	- 2	- 5	- 5	-13	
	4 PM.	- 6	- 4	+ 1	- 0	- 4	- 4	- 9	
	8 PM.	-12	- 9	- 3	- 2 $\frac{1}{2}$	- 7	- 6	-12	
14	8 AM.	- 2	- 0	+ 6	+ 5	- 4	- 3	- 5	
	4 PM.	- 2	- 1	- 6	- 3	- 4	- 3	- 5	
15	Noon	-10	- 8	- 1	- 2	- 5	- 5 $\frac{1}{2}$	-12	
	4 PM.	- 8	- 6	- 2	- 5	- 5	-11	- 4	
16	Noon	- 0	+ 2	+ 7	+ 6	+ 4 $\frac{1}{2}$	+ 4 $\frac{1}{2}$	- 3	
	4 PM.	+ 4	+ 6	+10 $\frac{1}{2}$	+ 9 $\frac{3}{4}$	+ 8	+ 8 $\frac{1}{2}$	+ 2	
	8 PM.	+ 6	+ 4	+13	+12	+ 7	+ 7	- 4	
17	8 AM.	+12	-14	-17	-16	-15	-15	- 8	
	1 PM.	- 6	- 4	-11	-10	- 9 $\frac{1}{2}$	- 9	- 3	
	4 PM.	- 4	- 2	+ 4	+ 3	- 0	- 0	- 6	
	8 PM.	- 8	- 6	- 0	- 0	- 5	- 5	- 9	



## Thermometers compared.

Year, Month, and Day.	Hours.	A.	B.	D.	E.	F.	G.	H.	
1782 Feb. 18	8 AM.	-12	-10	-2	-3	-5 $\frac{1}{2}$	-6	-12	
	Noon	-10	-8	-1	-2	-5	-5 $\frac{1}{2}$	-12	
	8 PM.	-22	-20	-11	-11	-16 $\frac{1}{2}$	-17	-22	
19	8 AM.	-34	-32	-21	-21 $\frac{1}{2}$	-29	-29	-33	
	Noon	-18	-16	-7	-8	-13	-13 $\frac{1}{2}$	-19	
	4 PM.	-12	-10	-3	-4	-8	-8	-14	
	8 PM.	-19	-17	-8	-8 $\frac{1}{2}$	-14	-14	-20	
20	8 AM.	-18	-16	-7 $\frac{1}{2}$	-8	-13	-13 $\frac{1}{2}$	-19	
	Noon	-0	+2	+7	+6	+4	+3 $\frac{1}{2}$	-4	
	4 PM.	-6	-4	+2	+1	-1	-1 $\frac{1}{2}$	-7	
	8 PM.	-8	-6	-0	-1	-4	-4	-10	
21	8 AM.	-30	-28	-17	-18	-25	-25	-30	
	Noon	-29	-27	-16 $\frac{1}{2}$	-17	-24	-24 $\frac{1}{2}$	-29	
	4 PM.	-28	-26	-17	-17	-23 $\frac{1}{2}$	-24	-28	
	8 PM.	-34	-32	-20	-21	-27	-27 $\frac{1}{2}$	-32	
22	7 AM.	-82	-66	-34	-34	-42	-42	-46	
	1 PM.	-35	-32	-21	-22	-30	-30	-34	
	4 PM.	-34	-32	-21	-22	-30	-30	-34	
	8 PM.	-39	-38	-24 $\frac{1}{2}$	-25 $\frac{1}{2}$	-34	-34	-36	
23	7 AM.	-44	-42	-28	-29	-40	-40	-42	
	4 PM.	-26	-24	-15	-16	-21	-21	-27	
	8 PM.	-35	-33	-21	-22	-30	-30	-34	
24	8 AM.	-42	-38	-26	-27	-36	-36	-40	
	1 PM.	-18	-16	-7	-8	-15	-15	-22	
	4 PM.	-12	-10	-3	-4	-8	-8	-14	
	8 PM.	-14	-12	-3 $\frac{1}{2}$	-4	-10	-10	-15	
25	8 AM.	-14	-12	-4	-5	-10	-10	-16	
	Noon	-4	-2	+3 $\frac{1}{2}$	+4 $\frac{1}{2}$	-0	-0	-7	
	4 PM.	-2	-0	+5	+4	+1	+1	-4	
	8 PM.	-6	-4	+3	+2	-1	-1	-7	
26	7 AM.	-22	-20	-11	-12	-18	-18	-22	
	4 PM.	-10	-8	-1	-2	-6	-6	-12	
	8 PM.	-18	-16	-7 $\frac{1}{2}$	-8	-14	-13	-17	
27	8 AM.	-24	-22	-13	-14	-20	-20	-25	
	Noon	-12	-10	-4	-5	-10	-10	-17	
	4 PM.	-14	-12	-4	-5	-10	-10	-15	
	8 PM.	-20	-18	-9 $\frac{1}{2}$	-10 $\frac{1}{2}$	-15	-15 $\frac{1}{2}$	-20	

Thermometers



Thermometers compared.

Year, Month, and Day.	Hours.	A.	B.	D.	E.	F.	G.	H.
1782								
Feb. 28	8 AM.	-20	-18	-9	-10	-15	-15 $\frac{1}{2}$	-22
	Noon	-8	-6	+1	-0	-4	-5	-11
	8 PM.	-12	-10	-6	-7	-10	-10	-12
Mar. 1	8 AM.	-6	-4	+3	+2	-2	-2	-8
	Noon	-6	-4	+3	-2	-2	-2	-7 $\frac{1}{2}$
	4 PM.	-14	-12	-4	-5	-10	-10	-14
	8 PM.	-18	-16	-8	-9	-14	-14	-18
2	9 AM.	-20	-23	-13 $\frac{1}{2}$	-14	-20	-21	-26
	4 PM.	-15	-12	-5	-6	-10	-10 $\frac{1}{2}$	-16
	8 PM.	-22	-20	-11	-12	-17	-17	-22
3	8 AM.	-36	-34	-22	-23	-31	-31 $\frac{1}{2}$	-35
	1 PM.	-12	-10	-2	-3	-7	-7	-16
	4 PM.	-10	-8	-2	-3	-6	-6	-12
	8 PM.	-18	-16	-7	-8	-13	-13 $\frac{1}{2}$	-18
4	8 AM.	-24	-22	-12	-13	-19 $\frac{1}{2}$	-20	-25
	Noon	-8	-6	-0	-1	-4 $\frac{1}{2}$	-5	-7
	4 PM.	-12	-10	-3	-4	-7 $\frac{1}{2}$	-8	-13
	8 PM.	-20	-18	-9	-10	-15	-15	-18
5	8 AM.	-32	-30	-19	-20	-26	-26	-30
	Noon	-16	-14	-6	-7	-12 $\frac{1}{2}$	-13	-19
	4 PM.	-14	-12	-4	-5	-10	-10	-16
	8 PM.	-18	-16	-8	-9	-14	-14	-19
6	8 AM.	-19	-17	-8 $\frac{1}{2}$	-9 $\frac{1}{2}$	-15	-15	-20
	Noon	-10	-8	-1	-2	-6	-6	-13
	4 PM.	-12	-10	-2	-3	-7 $\frac{1}{2}$	-8	-13
	8 PM.	-20	-18	-10	-11	-16	-16	-20
7	8 AM.	-19	-17	-8	-9	-15	-15	-21
	3 PM.	-3	-1 $\frac{1}{2}$	+5	+4	-0	-0	-8
	4 PM.	-0	+2	+7	+6	+4	+4	-3
	8 PM.	-0	+2	+7	+6	+4	+4	-3
8	Noon	+26	+28	+29 $\frac{1}{2}$	+28 $\frac{1}{2}$	+29	+28	+21
	4 PM.	+16	+18	+17	+17	+17	+17	+14
	8 PM.	-0	+2	+7	+6	+4	+4	+4
9	8 AM.	-29	-26	-16	-17	-24	-24 $\frac{1}{2}$	-28
	Noon	-14	-12	-4	-5	-10	-10	-16
	4 PM.	-11	-9	-2	-3	-6 $\frac{1}{2}$	-7	-13
	8 PM.	-16	-14	-6	-7	-12	-12	-16



Thermometers compared.

Year, Month, and Day.	Hours.	A.	B.	D.	E.	F.	G.	H.	
1782									
Mar. 10	8 AM.	-18	-16	-7	-6	-14	-14	-20	
	1 PM.	-4	-2	+5	+4	+1	+1	-5	
	4 PM.	+1	+4	+8	+7	+5	+5	-2	
11	4 PM.	-0	+2	+8	+7	+4	+4	-2	
	8 PM.	-2	-0	+5 $\frac{1}{2}$	+6 $\frac{1}{2}$	+3	+3	-4	
12	8 AM.	-2	-0	+5	+6	+3	+3	+4	
	Noon	+2	+4	+12	+11	+10	+9 $\frac{1}{2}$	+2	
	4 PM.	+2	+4	+9	+8	+6	+6	-0	
	8 PM.	-2	-0	+5 $\frac{1}{2}$	+5	+8	+7	-6	
13	8 AM.	-4	-2	+4	+3 $\frac{1}{2}$	-0	-0	-6	
	Noon	-0	+2	+7	+6	+4	+4	-3	
	4 PM.	-0	+2	+5	+4	+2 $\frac{1}{2}$	+2	-4	
	8 PM.	-7	-5	+2	+1	-3 $\frac{1}{2}$	-3	-14	
14	8 AM.	-18	-15	-7	-8	-12 $\frac{1}{2}$	-13	-18 $\frac{1}{2}$	
	Noon	-5	-3	+3	+2	-1	-1	-9	
	4 PM.	-6	-4	+2	+1 $\frac{1}{2}$	-2	-2	-8	
	8 PM.	-10	-7	-0	-1	-5	-5	-10	
15	8 AM.	+8	+9	+13	+12	+11	+11	+2	
	Noon	+25	+26	+27	+26	+27	+26	+19	
	4 PM.	+26	+27	+28	+27	+28	+27 $\frac{1}{2}$	+20	
	8 PM.	+26	+27 $\frac{1}{2}$	+29	+28	+28 $\frac{1}{2}$	+28	+20 $\frac{1}{2}$	
16	7 AM.	+7	+10	+13	+12	+10 $\frac{1}{2}$	+10	+6	
	4 PM.	+6	+8	+10	+10	-7	-7	-4	
	8 PM.	+3	+5	+9	+8	+6	+6	-0	
17	8 AM.	-4	-2	+4	+3	-0	-0	-6	
	1 PM.	-0	+2	+7	+6	+4	+4	-3	
	4 PM.	-0	+2	+6 $\frac{1}{2}$	+6	+4	+4	-3	
	8 PM.	-2	-0	+6 $\frac{1}{2}$	+5 $\frac{1}{2}$	+3	+3	-4	
18	8 AM.	-3	-1	+5	+4	+1	+1	-5	
	Noon	+5	+7	+11	+10	+10	+9	+1	
	4 PM.	+4	+6	+10 $\frac{1}{2}$	+9 $\frac{1}{2}$	+8	+8	+1	
	8 PM.	-2	-0	+5	+4	+2	+2	-4	
19	8 AM.	-9	-7	-0	-1	-4	-5	-10	
	Noon	-3	-1	+4 $\frac{1}{2}$	+3 $\frac{1}{2}$	+1	-0	-6	
	4 PM.	-4	-2	+4 $\frac{1}{2}$	+3 $\frac{1}{2}$	-1	-0	-6	
	8 PM.	-6	-4	+2	+1	-2	-2	-10	



Thermometers compared.

Year, Month, and Day.	Hour.	A.	B.	D.	E.	F.	G.	H.	
1782									
Mar. 20	8 AM.	- 4	- 2	+ 4 $\frac{1}{2}$	+ 3 $\frac{1}{2}$	- 0	- 0	- 6	
	4 PM.	+ 6	+ 8	+ 11 $\frac{1}{2}$	+ 10 $\frac{1}{2}$	+ 9	+ 8 $\frac{1}{2}$	+ 2	
	8 PM.	+ 2	+ 4	+ 9	+ 8	+ 6	+ 6	- 0	
21	8 AM.	+ 3	+ 5	+ 10	+ 9	+ 7	+ 6	- 0	
	Noon	+ 14	+ 16	+ 18 $\frac{1}{2}$	+ 17 $\frac{1}{2}$	+ 17	+ 16	+ 9	
	4 PM.	+ 14	+ 16	+ 19	+ 18	+ 19	+ 18	+ 11	
	8 PM.	+ 12	+ 14	+ 17	+ 16	+ 15	+ 14 $\frac{1}{2}$	+ 9	
22	Noon	+ 12	+ 14	+ 17	+ 16	+ 16	+ 15	+ 8	
	4 PM.	+ 14	+ 16	+ 19	+ 18	+ 18	+ 17	+ 11	
	8 PM.	+ 10	+ 12	+ 16	+ 15	+ 14	+ 14	- 8	
23	8 AM.	- 6	- 4	+ 3	+ 2	- 1	- 1	- 7	
	Noon	+ 4	+ 6	+ 11	+ 10	+ 9	+ 8 $\frac{1}{2}$	- 0	
	8 PM.	- 0	+ 2	+ 7	+ 6	+ 4	+ 4	- 2	
24	8 AM.	- 0	+ 2	+ 8	+ 7	+ 5	+ 4	- 3	



## Experiment I. made December 15, 1781.

Time per Watch.			Thermom. below 0.	Appara- tus.	Spirit Thermom.	Remarks and Occurrences.
h.	'	"				
9	22	0	25	23	—	Put them into a tumbler of snow.
9	31	0	—	—	—	Added the spirit of nitre.
9	32	0	60	40	—	Thermometer descends quick and equable.
9	32	20	88	40	—	
9	32	38	108	40	—	
9	32	55	120	40	—	
9	33	10	134	40	—	
9	33	29	150	40	—	
9	33	40	160	40	—	
9	34	0	176	40	—	
9	34	35	200	40	—	
9	34	57	214	40	—	
9	35	10	220	40	—	
9	35	50	252	40	—	
9	36	0	260	40	—	
9	36	29	280	40	—	
9	37	7	300	40	—	
9	37	48	320	40	—	
9	38	30	340	40	—	
9	39	6	352	40	—	
9	39	20	360	40	—	
9	39	48	370	40	—	
9	40	6	376	40	—	
9	40	38	384	40	—	
9	40	50	392	40	—	
9	41	19	400	40	—	
9	41	40	406	40	—	
9	42	10	414	40	—	
9	42	30	420	40	—	
9	43	0	426	40	—	
9	43	36	434	—	—	
9	44	0	438	40	—	
9	44	30	444	40	—	
9	45	0	448	40	—	
9	45	40	448	40	—	
9	54	0	448	40	—	



Experiment I. made December 15, 1781.

Time per Watch.	Thermom. below 0.	Apparatus.	Spirit Thermom.	Remarks and Occurrences.
h. / "				
9 55 0	448	40	—	Made a second freezing mixture.
9 56 15	448	40	—	Removed the instruments into the second mixture.
9 56 40	448	40	—	
9 57 0	448	40	—	
9 58 0	448	40	—	
9 58 40	448 $\frac{1}{2}$	40	—	
9 59 0	448 $\frac{1}{2}$	40	—	
10 0 0	448 $\frac{1}{2}$	40	—	
10 0 40	448 $\frac{1}{2}$	40	—	Added more spirit of nitre to the freezing mixture.
10 2 0	448 $\frac{1}{2}$	40	—	
10 3 35	448 $\frac{1}{2}$	40	—	{ Took the apparatus out of the freezing mixture, found it frozen, and immediately re-placed it.
10 4 14	448 $\frac{1}{2}$	42	—	
10 5 0	448	42	—	
10 7 10	448	41	—	
10 9 0	448	40	—	
10 9 40	448	40	—	
10 11 0	448	40	—	{ Took the apparatus out again, and endeavoured to withdraw the thermometer, but could not effect it, the quicksilver in the cylinder being frozen; put the apparatus again into the mixture.
10 11 34	448	40	—	
10 12 5	448	40	—	
10 12 20	448	40	—	
10 13 28	448	40	—	
10 15 0	—	—	—	Made a third freezing mixture.
10 16 15	444	40	—	
10 16 30	442	40	—	
10 17 10	440	40	—	
10 17 26	438	40	—	
10 17 40	—	—	—	Removed the instruments into the third mixture.
10 18 13	446	40	—	
10 18 40	448	40	—	
10 19 0	448	40	—	
10 20 0	448	40	—	Went away to warm myself.
10 26 0	448	43	—	Returned.
10 27 0	448	43	—	



## Experiment I. made December 15, 1781.

Time per Watch.			Thermom. below 0.	Appa- tus.	Spirit Thermom.	Remarks and Occurrences.
h.	'	"				
10	27	30	448	43	—	{ Put a spirit thermometer (D) into the freezing mixture along with apparatus and the mercurial thermometer.
10	28	0	448	43	14 $\frac{1}{2}$	
10	28	30	448	43	25	
10	28	40	448	43	28	
10	28	50	448	43	30	
10	29	0	448	43	31	{ Took out the spirit thermometer (D). Put in another spirit thermometer (E).
10	29	40	448	43	31 $\frac{1}{2}$	
10	30	0	447 $\frac{1}{2}$	42 $\frac{1}{2}$	31 $\frac{1}{2}$	
10	30	50	447 $\frac{1}{2}$	42 $\frac{1}{2}$	31	
10	31	30	447 $\frac{1}{2}$	42 $\frac{1}{2}$	18	
10	31	50	447 $\frac{1}{2}$	42	24	
10	32	0	447 $\frac{1}{2}$	42	28	
10	32	20	447 $\frac{1}{2}$	42	31	
10	32	40	447 $\frac{1}{2}$	42	31 $\frac{1}{2}$	
10	32	55	448	41 $\frac{1}{2}$	32	
10	33	20	448	41 $\frac{1}{2}$	32 $\frac{1}{2}$	{ Took out the spirit thermometer (E).
10	33	50	448	41 $\frac{1}{2}$	32 $\frac{1}{2}$	
10	34	0	448	41	32 $\frac{1}{2}$	
10	34	50	447 $\frac{1}{2}$	40 $\frac{1}{2}$	—	
10	35	20	447 $\frac{1}{2}$	40 $\frac{1}{2}$	—	
10	35	40	440	40	—	{ Removed the Instruments back into the second mixture.
10	35	49	433	40	—	
10	36	0	420	40	—	
10	36	20	410	40	—	
10	36	50	400	40	—	
10	37	8	392	40	—	
10	37	20	388	40	—	
10	37	40	380	40	—	
10	38	0	372	40	—	
10	38	20	366	40	—	
10	38	33	360	40	—	
10	40	0	324	40	—	
10	42	0	270	40	—	
10	43	0	260	40	—	
10	44	0	248	40	—	



Experiment I. made December 15, 1781.

Time per Watch.	Thermom. below O.	Apparatus.	Spirit Thermom.	Remarks and Occurrences.
h. ' "				
10 44 15	244	40	—	Removed the instruments back to the 3d mixture.
10 44 35	246	40	—	
10 45 0	248	40	—	
10 46 0	247	40	—	
10 47 0	247	40	—	
10 48 0	246½	40	—	
10 49 0	246	40	—	
10 50 0	246	40	—	
10 51 0	245½	40	—	
10 52 0	245½	40	—	
10 53 0	244	40	—	
10 55 0	244	40	—	
10 55 20	244	40	—	
11 4 0	114	38	—	Went away, to warm myself. Returned.
11 9 0	54	37	—	Put in the spirit thermometer (D).
11 9 50	48	37	—	
11 11 0	40	36	—	
11 12 0	39	35½	—	
11 13 0	—	—	24	
11 13 40	38	35½	—	{ Took out the apparatus; the quicksilver was perfectly fluid, and the inclosed thermometer (F) was easily withdrawn.
11 14 0	38	—	26½	

*Remarks and observations on the first experiment.*

Finding the thermometer on Thursday evening, the 14th of December, was 18° below the cypher, I concluded the morning would afford me an opportunity to make an attempt to fix the point at which quicksilver begins to freeze; I therefore put a bottle of spirit. nitri fortis upon the top of the house in open air, that it might be of the same temperature when it was to be



used. The thermometer had been hung up before, three weeks, in the open air, to compare their scales. At 7 o'clock in the morning of the 15th, the thermometers were about  $23^{\circ}$  below nought; I therefore made preparations for the experiments, getting the quicksilver out into the air, providing glass tumblers for mixing the nitrous acid with the snow, &c. I put as much quicksilver into a glass cylinder as (when the thermometer (F) was introduced) just filled the bulbous part of the cylinder; the scale of the thermometer did not reach the length of the tube by about three inches; and the bare part of the tube was wound round with red worsted in two places, to a thickness sufficient to fill the upper part of the orifice of the cylinder in order to exclude the external air: now, as the quicksilver only filled the bulb, there was a space of near half an inch left empty between the quicksilver and the nearest piece of worsted, so that, by inclining the apparatus, the quicksilver readily ran out of the bulb into the other part of the cylinder. This was done with an intention to discover the more easily when the quicksilver ceased to be fluid; for, by taking the instrument out of the freezing mixture, and elevating the lower end, the quicksilver, if not frozen, would run into the void space.

The experiment was made in the open air, on the top of the Fort, with only a few deer-skins sewed together, placed to windward for a shelter: there was plenty of snow (eighteen inches deep) upon the works, and the thermometers were close at hand. In thrusting the thermometer (F) into the quicksilver, the instrument rose to the cypher, but soon began to descend again; but being unwilling to lose time, I stuck the apparatus into the snow, the sooner to bring it to the temperature of the air.

The



The table will fully explain the process. I was in hopes, by shifting the instruments into three fresh mixtures, I should have been able to have produced a greater degree of cold than by one only; yet it did not. I added more spirit of nitre, but without effect. At 10 h. 3' 35" I took out the apparatus, and raised the bulbous end to make the quicksilver run, but found it was frozen, so that it did not alter its figure in the least. I then placed it in the mixture, where it continued till 10 h. 11', when I made another trial as before, but without perceiving any alteration: however, to be more certain of its being frozen, I proposed to take out the thermometer; but all the strength in my fingers could not move it in the least, so that myself and officers, who stood by, were convinced it was frozen fast. I then made another mixture in hopes to augment the cold, and make the inclosed thermometer (F) descend; however, seeing no alteration, I went into the house to warm myself, and on my return found it had fallen 3°. I tried the coldness of the mixture by different spirit thermometers, and afterwards shifted the instruments into the mixture from whence I had taken them; but this diminished the cold by the thermometer, so that I re-placed them again in the third mixture, and the quicksilver in the thermometer descended again to its former point 448°. I continued observing it some minutes, when the cold obliged me a second time to retire, and on my return found both the thermometer and apparatus rising: on dipping a spirit thermometer into the mixture, I found it had a considerable degree of coldness, and both the apparatus and mercurial thermometers were nearly equal. I then took them out, and the quicksilver in the cylinder was as fluid as when it was first poured in.

I should have observed, that during the time I was pouring in the spirit of nitre at the beginning of the operation, I was



so engaged in mixing it with the snow, that I did not see the thermometer in the apparatus sink to  $40^{\circ}$ , which must have been very sudden, because I was but one minute before I observed it. I could observe no alteration in the quicksilver in the cylinder when it was frozen, and intending to make more experiments, I was unwilling at this time to break the glass.

The time was taken by a good watch which shews seconds, and (which however I apprehend can be of little consequence) about  $5' 10''$  too fast by apparent time. I had two assistants; one to repeat audibly every second, and the other to write down the time and the observations as fast as I made them.

The observations were taken down with a pencil, but copied fair with ink into my note book: they were compared the same day the experiment had been made, to avoid mistakes; and these remarks were written at the same time, whilst the remembrance of them was yet strong on the mind.

The thermometers used on this occasion were those marked **A** and **F**.



Experiment II. made Dec. 16, 1781.

Time per Watch.	Thermom. below 0.	Apparatus.	Spirit Thermom.	Remarks and Occurrences.
h.				
8 19 30	34	31	—	Put the instruments into a tumbler of snow.
8 21 30	—	—	—	Began to pour in the spirit. nitri fortis.
8 21 45	40	34	—	
8 22 12	40	36	—	
8 22 40	40	36	—	
8 23 0	32	32	—	A large proportion of spirit of nitre poured in.
8 23 31	38	29	—	Adding snow to the mixture, it being too thin.
8 23 50	40	30	—	
8 24 0	43	34	—	
8 24 15	44	36	—	
8 24 40	58	40	—	
8 24 50	66	43	—	
8 25 0	76	43	—	
8 25 19	80	40	—	
8 25 29	84	40	—	
8 25 46	90	40	—	
8 26 0	94	40	—	
8 26 12	100	40	—	
8 26 24	104	40	—	
8 26 43	110	40	—	
8 27 0	116	40	—	{ Added more snow, the quantity of the mixture being small.
8 27 22	126	40	—	
8 27 42	138	40	—	
8 28 0	146	40	—	
8 28 29	158	40	—	
8 28 45	164	40	—	
8 29 0	168	40	—	
8 29 25	176	40	—	
8 29 52	180	40	—	
8 30 20	184	40	—	{ Found the mixture did not cover the bulb of the mercurial thermometer.
8 30 50	210	40	—	Poured in more spirit of nitre.
8 31 20	160	40	—	
8 31 28	156	40	—	Put in snow by degrees, and stirred the mixture.
8 31 43	148	40	—	Ditto,
8 32 0	152	40	—	



## Experiment II. made December 16, 1781.

Time per Watch.	Thermom. below O.	Apparatus.	Spirit Thermom.	Remarks and Occurrences.
h. ' "				
8 32 10	156	40	—	
8 32 20	162	40	—	
8 32 31	168	40 $\frac{1}{2}$	—	
8 32 48	178	42 $\frac{1}{2}$	—	
8 33 0	188	43	—	
8 33 15	194	44	—	
8 33 26	200	44 $\frac{1}{2}$	—	
8 33 39	206	92	—	{ The mercury in the apparatus thermometer sunk so instantaneously, I could not catch any intermediate degrees.
8 33 47	206	95	—	
8 34 0	206	95	—	
8 34 21	206	95	—	
8 34 35	206	95	—	
8 35 0	206	95	—	
8 35 30	206	95	—	
8 36 0	206	95	—	
8 36 30	206	95	—	Put in the spirit thermometer D.
8 37 0	206	95	30	
8 37 30	206	95	32	
8 38 0	206	95	33	
8 38 30	206	95	33	
8 39 0	206	95	33	Made a fresh freezing mixture.
8 40 0	206	95	33	Removed all the instruments into it.
8 41 0	206	95	33	
8 42 0	206	95	33	
8 43 0	206	95	33	
8 44 0	206	95	33	
8 45 0	206	95	33	
8 46 0	206	95	33	
8 46 30	206	95	33	{ Took out the apparatus, and found the quicksilver in the cylinder frozen; replaced it.
8 46 54	206	95	33	
8 47 0	206	95	33	{ From 8 h. 47' to 9 h. 11' employed in making the next experiment.
8 48 0	206	95	33	



Experiment II. made December 16, 1781.

Time <i>per</i> Watch.	Thermom. below C.	Appara- tus.	Spirit Thermom.	Remarks and Occurrences.
h. , "				
9 11 0	206	95	32 $\frac{1}{2}$	{ Went to breakfast, and, seeing no alteration, intended only to return now and then, it being Sunday, and prayer time being at hand.
9 50 0	206	95	31 $\frac{1}{2}$	
10 35 0	378	Bulb	27	
10 37 10	348	D°	—	{ Took the apparatus out to examine it; then put it in again.
10 38 0	320	D°	—	
10 38 40	310	D°	—	Stirred the instruments about in the mixture.
10 39 30	306	D°	—	
10 40 30	296	D°	—	
10 41 20	290	D°	27	
10 41 50	284	D°	—	
10 42 15	280	D°	27	
10 43 0	273	D°	—	
10 43 50	260	D°	—	
10 44 50	250	D°	—	
10 46 10	234	D°	—	
10 46 40	227	D°	—	
10 47 0	222	D°	26	
10 47 30	216	D°	26	
10 48 15	206	D°	—	
10 48 35	202	D°	—	
10 49 10	194	D°	—	
10 49 30	189	D°	26	
10 50 0	182	D°	—	
10 50 20	177	D°	—	
10 50 50	170	D°	26	
10 51 15	164	D°	—	
10 51 40	156	D°	26	
10 52 20	147	D°	—	
10 52 50	141	D°	—	
10 55 5	112	D°	25 $\frac{1}{4}$	
10 55 30	107	D°	—	
10 56 0	102	D°	—	
10 56 15	98	D°	25	
10 56 35	94	D°	—	
10 56 50	91	D°	—	



Experiment II. made December 16, 1781.

Time per Watch.			Thermom. below 0.	Appara- tus.	Spirit Thermom.	Remarks and Occurrences.
h.	'	"				
10	57	10	86	Bulb	—	
10	57	30	82	D°	—	
10	57	45	79	D°	25	
10	58	5	75	D°	—	
10	58	30	70	D°	—	
10	58	45	67	D°	—	
10	59	10	62	D°	—	
10	59	30	58	D°	—	
11	0	0	53	D°	—	
11	0	15	50	D°	—	
11	0	40	47	D°	24 $\frac{1}{2}$	
11	1	0	44	D°	24 $\frac{1}{2}$	
11	1	20	41	D°	—	
11	2	0	40	D°	—	
11	2	30	39	D°	—	
11	3	0	39	D°	—	
11	3	30	39	D°	—	
11	4	0	38 $\frac{1}{2}$	D°	—	{ The mercury in the apparatus thermometer raising up the tube from the bulb.
11	4	20	38	235	—	
11	4	30	38	225	—	
11	4	40	38	220	—	
11	4	50	38	218	—	
11	5	0	38	205	—	
11	5	10	38	195	—	
11	5	20	38	183	—	
11	5	33	38	172	—	
11	5	44	38	163	—	
11	5	55	38	154	—	
11	6	10	38	140	—	
11	6	20	38	130	—	
11	6	30	37	120	—	
11	6	40	37	110	—	
11	6	50	37	97	—	
11	7	0	37	87	—	
11	7	10	37	78	—	
11	7	20	37	67	—	



Experiment II. made December 16, 1782.

Time per Watch.		Thermom. below 0.	Apparatus.	Spirit Thermom.	Remarks and Occurrences.
h.	"				
II	7 40	37	47	—	
II	8 0	37	38	—	
II	8 20	37	38	—	
II	8 40	37	38	23 $\frac{1}{2}$	
II	9 15	37	37 $\frac{1}{2}$	—	
II	9 30	37	37	—	{ Examined apparatus, quicksilver in the cylinder perfectly fluid.
II	15 0	36	35	23	

This experiment was made with the same instruments as the preceding, and the quicksilver which was left yesterday in the cylinder was the same now employed. I was rather unfortunate in making too small a quantity of the freezing mixture at the beginning, which obliged me to make repeated additions to it: by this means the operation was not only retarded, but sometimes it even undid what had been done; for in pouring in the nitrous acid it was unavoidable but part of it should come in contact with the bulbs of the instruments before it was mixed with snow. In this case it never failed making the thermometers rise suddenly much higher than where they stood before the spirit was added; and at length it only descended to 206°, which is not half so low as on the preceding day, though the temperature of the air was ten degrees colder (*viz.* 34°): yet it is remarkable, that though the thermometer was so much higher, the apparatus was sunk more than twice as low as the day before; for after having been long stationary at 40°, it sunk



\*328 *Mr. HUTCHINS's Experiments for ascertaining*

to 95°. I then made a fresh mixture, but it had no effect any way during three quarters of an hour I attended to it afterwards. During this idle interval I made the third experiment. Finding no alteration, I went down to breakfast, and on my return was surpris'd to find the quicksilver in the apparatus thermometer had subsided into the bulb, and the standard thermometer had been very low (how low I cannot tell), and was rising briskly. The spirit thermometer also shewed the mixture had a less degree of cold than before. To be certain that the quicksilver in the apparatus thermometer was in the bulb, I took the apparatus out of the mixture, and examined it minutely for half a minute, till I was quite certain of it; and also that the quicksilver in the cylinder was frozen, and it is remarkable, it did not liquify in all that time.

The observations were made with the greatest attention, and (on every particular occasion) noted down as quick as possible.



Experiment III. made December 16, 1781.

Time per Watch.			Thermom. below 0.	Apparatus.	Spirit Thermom.	Remarks and Occurrences.
h. , "			B.	G.	E.	
8	55	55	34	35	—	{ Put them into the first freezing mixture used in the preceding experiment.
8	56	10	40	40	—	
8	56	21	41	41	—	
8	56	42	42	42	—	
8	57	0	43	42½	—	
8	57	26	43	43	—	
8	58	0	43	43	—	
8	58	58	54	43	—	
8	59	14	60	43	—	
8	59	40	64	43	—	
9	0	0	68	43	—	
9	0	34	70	43	—	
9	1	0	75	43	—	
9	1	22	78	43	—	
9	2	0	82	43	—	
9	2	30	85	43	—	
9	3	0	88	43	—	
9	4	0	94	43	—	Put the spirit thermometer (E) into the mixture.
9	4	21	94	43	27	
9	4	40	98	43	30	
9	5	12	100	43	31½	
9	6	0	104	43	32	
9	6	30	106	43	32	
9	7	0	108	43	32	
9	7	40	110	43	32	
9	8	20	112	43	—	
9	9	0	114	43	—	
9	10	30	116	40	—	{ The quicksilver in the apparatus was fluid, but seemed thick and in grains, somewhat like crumbs of bread; replaced it again, and went to breakfast. Examined the quicksilver again, it was frozen hard. The quicksilver as fluid as ever.
9	50	0	40	40	—	
10	55	40	—	37½	—	

This experiment was made during the continuance of that which immediately precedes it, as may be seen by examining



the time by the watch, and was the effect of chance; for the first freezing mixture, which had been used in the second experiment, standing in the glass close to me (and the other instruments being long stationary, did not require particular attention), I took down the thermometer (G) and charged its cylinder with quicksilver, as in the other examples, and suspended it in the old mixture, together with the mercurial thermometer (B) and a spirit thermometer; the mixture seemed to have lost much of its coldness, as appeared by the thermometers. It seemed very extraordinary to me, that the apparatus, after having been so long stationary at  $43^{\circ}$ , should yet contain fluid quicksilver; but both myself and assistant thought it was thicker than ordinary, as it did not run freely, but seemingly in pieces (not globules): however we put it back again into the mixture, and set it by as of no further use; but returning after breakfast, we found it was firmly frozen, so as to give no appearance of fluidity though the included thermometer was only at  $40^{\circ}$ , which I look upon to be the exact freezing point of quicksilver; and then the congelation was in fact begun before, and effected by only a longer continuance in the same degree of cold.

It may be necessary to mention, that the space between the bottom of the ivory scale to the bulb of the thermometer (F) which made part of the apparatus used in the second experiment, was two inches nine-tenths; and when taken with a pair of compasses (dividers) with one foot placed at the cypher 0 on the graduated scale, the other extended to  $148^{\circ}$  if measured upwards, and to  $165^{\circ}$  if measured downwards, for the divisions were unequal.



Experiment IV. made January 7, 1782.

Time per watch.	Thermom. below O.	Apparatus.	Spirit Thermom.	Remarks and Occurrences.
h. ' "				
8 7 0	35	30	—	Put the instruments into a tumbler of snow.
8 9 45	35 $\frac{1}{2}$	27	—	
8 10 40	—	—	—	Added the spirit of nitre.
8 11 0	42	42	—	{ Added more snow to increase the quantity of the mixture.
8 12 30	—	—	—	Added more spirit.
8 13 15	68	42	—	
8 13 35	78	42	—	
8 14 0	92	42	—	
8 14 15	100	42	—	
8 14 30	108	42	—	
8 14 45	116	42	—	
8 15 0	126	42	—	
8 15 15	134	42	—	
8 15 30	140	42	—	
8 15 45	146	41 $\frac{1}{2}$	—	
8 16 20	160	41 $\frac{1}{2}$	—	
8 16 30	166	41 $\frac{1}{2}$	—	
8 16 45	171	41 $\frac{1}{2}$	—	
8 17 15	182	41 $\frac{1}{2}$	—	
8 17 45	191	41 $\frac{1}{2}$	—	
8 18 0	196	41 $\frac{1}{2}$	—	
8 18 15	202	41 $\frac{1}{2}$	—	
8 18 30	208	41 $\frac{1}{2}$	—	
8 18 45	212	41 $\frac{1}{2}$	—	
8 19 30	232	77	—	The descent in the apparatus therm. very quick.
8 19 40	240	77	—	
8 20 30	258	77 $\frac{1}{2}$	—	
8 20 40	262	77 $\frac{1}{2}$	—	
8 21 0	270	77 $\frac{1}{2}$	—	
8 21 15	278	77 $\frac{1}{2}$	—	
8 21 45	280	77 $\frac{1}{2}$	—	
8 22 0	286	77 $\frac{1}{2}$	—	
8 22 30	293	77 $\frac{1}{2}$	—	
8 22 35	298	77 $\frac{1}{2}$	—	
8 23 0	302	78	—	
8 23 15	305	78	—	



Experiment IV. made January 7, 1782.

Time <i>per</i> Watch.		Thermom. below 0.	Appara- tus.	Spirit Thermom.	Remarks and Occurrences.
h.	"				
8	23	30	309	78	—
8	24	0	316	78	—
8	24	15	319	78	—
8	24	30	322	78	—
8	24	45	327	78	—
8	25	0	329	78	—
8	25	15	332	78	—
8	25	30	336	78	—
8	25	45	338	78	—
8	26	0	342	78	—
8	26	15	345	78	—
8	26	30	348	78	—
8	26	45	351	78	—
8	27	0	354	78	—
8	27	15	356	78	—
8	27	30	359	78	—
8	27	45	361	78	—
8	28	0	364	78	—
8	28	15	366	78	—
8	28	30	368	78	—
8	28	45	370	78	—
8	29	0	373	77	—
8	29	15	376	77	—
8	29	30	378	77	—
8	29	45	380	77	—
8	30	15	386	77	—
8	30	30	388	77	—
8	31	0	392	77	—
8	31	15	394	76 $\frac{1}{2}$	—
8	31	30	396	76 $\frac{1}{2}$	—
8	31	45	398	76 $\frac{1}{2}$	—
8	32	15	402	76 $\frac{1}{2}$	—
8	32	30	403	76	—
8	32	45	404	76	—
8	33	0	406	76	—
8	33	15	408	76	—
8	34	0	412	76	—
				31 $\frac{1}{2}$	

Stirred the mixture.

Put in spirit thermometer (D).



Experiment IV. made January 7, 1782.

Time per Watch.			Thermom. below 0.	Appara- tus.	Spirit Thermom.	Remarks and Occurrences.
h.	'	"				
8	34	30	416	76	32	
8	35	0	418	76	32	
8	35	30	422	76	32	
8	36	0	424	76	32	
8	36	15	425	76	32	
8	36	30	425	76	32	
8	36	45	427	76	32	
8	37	0	428	76	32	
8	37	15	429	76	32	
8	37	30	430	76	32	
8	37	45	430	76	32	
8	38	0	431	76	32	
8	38	30	432	76	32	
8	38	45	433	76	32	
8	39	0	434	76	32	
8	39	15	435	76	32	
8	39	30	435½	76	32	
8	40	0	436	76	32	
8	40	30	436	76	32	
8	40	45	437	76	32	
8	41	15	438	76	32	
8	41	30	438½	76	32	
8	41	45	439	76	31½	
8	42	15	440	76	31½	
8	43	0	440	76	31½	
8	43	15	440	75½	31½	
8	44	30	440	75½	31	Made a fresh mixture.
8	47	0	438	75	31	Removed the instr. into the new freezing mixture.
8	47	36	448	76	34½	
8	48	0	448	76½	35	
8	48	30	448	77	35	
8	49	0	448	77	35	
8	49	30	449	77	35	
8	50	0	449	77	35	
8	50	30	450	77	35	
8	51	0	450	77	35	
8	52	0	450	77	35	



## Experiment IV. made January 7, 1782.

Time per Watch.	Thermom. below O.	Apparatus.	Spirit Thermom.	Remarks and Occurrences.
h. / "				
8 53	○ 45°	77	35	
8 54	○ 45°	77	35	
8 56	○ 45°	77	35	
8 57	○ 45°	77	35	
8 58	○ 45°	77	35	
8 59	○ 45°	77	35	
9 0	○ 45°	77	35	
9 1	○ 45°	77	35	
9 2	○ 45°	77	35	
9 3	○ 45°	77	35	
9 4	○ 45°	77	35	
9 5	○ 45°	77	35	
9 6	○ 45°	77	35	
9 7	○ 45°	77	35	Examined the apparatus; found all solid.
9 8	○ 45°	77	35	
9 9	○ 45°	77	35	
9 10	○ 45°	77	35	
9 11	○ 45°	77	35	
9 12	○ 45°	77	35	
9 13	○ 45°	77	35	
9 14	○ 45°	77	35	
9 15	○ 45°	77	35	
9 16	○ 45°	77	35	
9 17	○ 45°	77	35	
9 18	○ 45°	77	35	
9 19	○ 45°	77	35	
9 20	○ 45°	77	35	
9 21	○ 45°	77	35	
9 22	○ 45°	77	35	
9 23	○ 45°	77	35	Added more snow.
9 23 30	○ 45°	77	35	
9 24	○ 45°	77	34½	
9 25	○ 45°	77	34½	
9 26	○ 45°	77	34½	
9 27	○ 45°	77	34½	
9 28	○ 45°	77	34½	



Experiment IV. made January 7, 1782.

Time <i>per</i> Watch.		Thermom. below 0.	Appara- tus.	Spirit Thermom.	Remarks and Occurrences.
h.	'				
9	29	0	450	77	34 $\frac{1}{2}$
9	30	0	450	77	34 $\frac{1}{2}$
9	31	0	450	77	34 $\frac{1}{2}$
9	32	0	450	77	34 $\frac{1}{2}$
9	33	0	450	77	34 $\frac{1}{2}$
9	34	0	450	77	34 $\frac{1}{2}$
9	35	0	450	77	34 $\frac{1}{2}$
9	36	0	450	77	34 $\frac{1}{4}$
9	37	0	449	77	34
9	38	0	449	77	33 $\frac{1}{2}$
9	39	0	449	77	33
9	40	0	449	77	33
9	41	0	449	77	32 $\frac{1}{2}$
9	42	0	449	77	32 $\frac{1}{2}$
9	43	0	448 $\frac{1}{2}$	76	32 $\frac{1}{2}$
9	44	0	448 $\frac{1}{2}$	76	32 $\frac{1}{2}$
9	45	0	448 $\frac{1}{2}$	76	32 $\frac{1}{2}$
9	46	0	448 $\frac{1}{2}$	76	32
9	47	0	448 $\frac{1}{2}$	76	32
9	48	0	448 $\frac{1}{2}$	76	32
9	49	0	448 $\frac{1}{2}$	76	32
9	50	0	448 $\frac{1}{2}$	76	31 $\frac{1}{2}$
9	51	0	448 $\frac{1}{2}$	76	31 $\frac{1}{2}$
9	52	0	448	75 $\frac{1}{2}$	31 $\frac{1}{2}$
9	53	0	448	75 $\frac{1}{2}$	31 $\frac{1}{2}$
9	54	0	448	75	31 $\frac{1}{4}$
9	56	0	448	75	31
9	57	0	447	75	31
9	58	0	445	75	30 $\frac{3}{4}$
9	58	30	444	75	30 $\frac{3}{4}$
9	58	45	443	75	30 $\frac{3}{4}$
9	59	0	442	75	30 $\frac{3}{4}$
9	59	15	441	75	30 $\frac{3}{4}$
9	59	30	440	75	30 $\frac{1}{2}$
9	59	45	439	75	30 $\frac{1}{2}$
10	0	0	438	75	30 $\frac{1}{2}$
10	0	15	437	75	30 $\frac{1}{2}$



## Experiment IV. made January 7, 1782.

Time per Watch.		Thermom. below 0.	Appara- tus.	Spirit Thermom.	Remarks and observations.
h.	' "				
10	0 30	436	75	30 $\frac{1}{2}$	
10	0 45	435	75	30 $\frac{1}{2}$	
10	1 0	434	75	30 $\frac{1}{2}$	
10	1 15	433	75	30 $\frac{1}{2}$	
10	1 30	432	75	30 $\frac{1}{4}$	
10	1 45	431	75	30 $\frac{1}{4}$	
10	2 0	430	75	30	
10	2 15	429	75	30	
10	2 45	426	74	30	
10	3 30	422	74	30	
10	4 15	417	74	30	
10	4 45	414	74	30	
10	5 0	412	74	30	
10	5 30	408	73 $\frac{1}{2}$	30	
10	6 0	405	73 $\frac{1}{2}$	30	
10	6 30	401	73 $\frac{1}{2}$	29 $\frac{1}{2}$	Filled up the tumbler with a former mixture.
10	7 30	388	73	28 $\frac{1}{2}$	
10	8 0	382	74	28	
10	8 30	377	82	28	
10	8 46	374	87	28	
10	9 0	368	110	28	
10	9 10	366	125	28	
10	9 20	364	170	28	
10	9 40	360	200	28	
10	9 50	358	240	28	
10	10 0	356	Bulb	28	
10	10 30	350	D°	28	
10	11 10	340	D°	28	
10	12 0	332	D°	28	
10	12 30	327	D°	28	
10	13 0	321	D°	28	
10	13 30	316	D°	28	
10	14 0	311	D°	28	
10	14 30	306	D°	28	
10	15 0	301	D°	28	
10	15 30	296	D°	28	Made a fresh mixture.
10	16 0	—	D°	28	Put the instruments into a fresh mixture.



Experiment IV. made January 7, 1782.

Time <i>per</i> Watch.			Thermom. below 0.	Appara- tus.	Spirit Thermom.	Remarks and Occurrences.
h.	'	"				
10	16	30	312	Bulb	29	
10	17	0	352	D°	35	
10	17	45	373	D°	35	
10	18	0	384	D°	35	
10	18	15	389	D°	35	
10	18	30	389	D°	35	
10	18	45	389	D°	35	
10	19	0	389	D°	35	
10	20	0	389	D°	35	
10	20	30	389	D°	35	
10	21	0	389	D°	35	
10	22	0	389	D°	35	
10	23	0	389	D°	35	
10	24	0	389	D°	35	
10	25	0	389	D°	35	
10	26	0	389	D°	35	
10	27	0	389	D°	35	
10	28	0	389	D°	35	
10	29	0	389	D°	35	
10	30	0	389	D°	35	
10	31	0	389	D°	35	
10	32	0	389	D°	35	
10	33	0	389	D°	35	
10	34	0	389	D°	35	
10	35	0	389	D°	35	
10	36	0	389	D°	35	
10	37	0	389	D°	35	
10	38	0	389	D°	35	
10	39	0	389	D°	35	
10	40	0	389	D°	35	
10	41	0	389	D°	35	
10	42	0	389	D°	35	
10	43	0	389	D°	35	
10	44	0	389	D°	34 $\frac{1}{2}$	
10	45	0	389	D°	34 $\frac{1}{2}$	
10	46	0	389	D°	34 $\frac{1}{2}$	



## Experiment IV. made January 7, 1782.

Time per Watch.	Thermom. below 0.	Apparatus.	Spirit Thermom.	Remarks and Occurrences.
h. / "				
10 47 0	389	Bulb	34 $\frac{1}{2}$	
10 48 0	389	D°	34 $\frac{1}{2}$	
10 49 0	389	D°	34 $\frac{1}{2}$	
10 50 0	389	D°	34	
10 51 0	389	D°	34	
10 52 0	389	D°	34	
10 53 0	288	D°	34	
10 55 0	288	D°	33 $\frac{1}{2}$	
10 59 0	288	D°	33 $\frac{1}{4}$	
11 1 0	288	D°	33	
11 5 0	388	D°	32 $\frac{1}{2}$	
11 10 0	388	D°	32	
11 15 0	444	D°	31 $\frac{1}{2}$	
11 15 10	446	D°	31	
11 15 30	445	D°	31	
11 15 45	444	D°	31	
11 16 15	443	D°	31	
11 17 0	441	D°	31	
11 18 0	437	D°	31	
11 19 0	434	D°	30	
11 20 0	428	D°	30	
11 21 30	418	D°	29 $\frac{1}{2}$	{ Whilst examining the apparatus, part of the quicksilver turned fluid.
11 22 30	412	D°	29 $\frac{1}{2}$	
11 23 0	408	D°	29 $\frac{1}{2}$	
11 23 30	404	D°	29 $\frac{1}{4}$	
11 24 0	400	D°	29	
11 24 30	396	D°	29	
11 25 30	390	D°	29	{ The center of the quicksilver appeared globular and solid.
11 26 30	379	D°	29	
11 28 0	365	D°	29	
11 29 0	355	D°	29	
11 29 30	352	D°	29	
11 29 45	349	D°	29	
11 30 0	346	D°	29	



Experiment IV. made January 7, 1782.

Time <i>per</i> Watch.	Thermom. below 0.	Appara- tus.	Spirit Thermom.	Remarks and Occurrences.
h. / "		Bulb		
II 30 15	344	D°	29	
II 30 30	342	D°	29	
II 30 45	339	D°	29	
II 31 0	336	D°	29	
II 31 15	333	D°	29	
II 31 30	330	D°	29	
II 31 45	328	D°	29	
II 32 0	325	D°	29	
II 32 30	320	D°	29	
II 32 45	318	D°	29	
II 33 0	314	D°	29	
II 33 15	312	D°	29	
II 33 30	309	D°	28 $\frac{1}{2}$	
II 33 45	306	D°	28 $\frac{1}{2}$	
II 34 0	303	D°	28 $\frac{1}{2}$	
II 34 15	301	D°	28 $\frac{1}{2}$	
II 34 30	298	D°	28 $\frac{1}{2}$	
II 34 45	295	D°	28 $\frac{1}{2}$	
II 35 0	292	D°	28 $\frac{1}{2}$	
II 35 15	289	D°	28 $\frac{1}{2}$	
II 35 30	286	D°	28 $\frac{1}{2}$	
II 35 45	283	D°	28 $\frac{1}{2}$	
II 36 0	280	D°	28 $\frac{1}{2}$	
II 36 15	277	D°	28 $\frac{1}{2}$	
II 36 30	274	D°	28 $\frac{1}{2}$	
II 37 0	267	D°	28 $\frac{1}{2}$	
II 37 15	264	D°	28 $\frac{1}{2}$	
II 37 30	262	D°	28 $\frac{1}{2}$	
II 37 45	258	D°	28 $\frac{1}{4}$	
II 38 0	255	D°	28	
II 38 15	252	D°	28	
II 38 30	249	D°	28	
II 38 45	246	D°	28	
II 39 0	241	D°	28	
II 39 30	237	D°	28	
II 39 45	234	D°	28	



## Experiment IV. made January 7, 1782.

Time per Watch.		Thermom. below 0°.	Appa- tus.	Spirit Thermom.	Remarks and Occurrences.
h.	"				
11	40	0	231	D°	28
11	40	30	224	D°	28
11	41	0	216	D°	28
11	41	30	211	D°	28
11	42	0	204	D°	27 $\frac{1}{2}$
11	42	30	197	D°	27 $\frac{1}{2}$
11	43	0	190	D°	27 $\frac{1}{2}$
11	43	30	185	D°	27 $\frac{1}{2}$
11	44	0	178	D°	27 $\frac{1}{2}$
11	44	30	170	D°	27
11	45	0	160	D°	27
11	45	30	150	D°	27
11	46	0	142	D°	27
11	46	30	134	D°	27
11	47	0	125	D°	27
11	47	30	118	D°	27
11	48	0	109	D°	27
11	48	30	103	D°	27
11	49	0	96	—	27
11	49	15	90	227	27
11	49	30	88	215	27
11	49	40	86	205	27
11	49	50	84	193	27
11	50	0	82	180	27
11	50	10	80	170	27
11	50	20	78	157	27
11	50	30	73	145	27
11	50	40	73	132	27
11	50	50	72	120	27
11	51	0	69	105	27
11	51	10	68	88	27
11	51	20	64	65	27
11	51	35	62	45	27
11	51	50	59	37 $\frac{1}{2}$	27
11	52	0	56	38	27

{ The quicksilver in the apparatus thermometer rising fast in the tube.



Experiment IV. made January 7, 1782.

Time per Watch.	Thermom. below 0.	Apparatus.	Spirit Thermom.	Remarks and Occurrences.
h. / "				
11 52 30	53	38	27	Found the quicksilver wholly thawed in the cylinder.
11 53 0	46	38	27	
11 53 30	42	37	27	
11 54 0	40	37	26½	
11 54 30	39	37	26½	
11 55 0	39	37	26½	
11 55 30	39	37	26½	
11 56 0	39	37	26½	
11 56 30	38	36	26	

This experiment was made with the mercurial thermometer (A) and the apparatus (F) as in the first and second experiments. The day was clear, with little wind at W. by S. or W.S.W. which I have observed to be generally the case in this country in the coldest weather. The thermometers at 8 o'clock were as follows, according to the rotation of the letters from (A) to (G),  $39^{\circ}\frac{1}{2}$ ,  $36^{\circ}\frac{1}{2}$ ,  $35^{\circ}$ ,  $25^{\circ}$ ,  $25^{\circ}$ ,  $34^{\circ}\frac{1}{2}$ ,  $34^{\circ}$  below the cypher. The apparatus thermometer (F), after standing at  $42^{\circ}$  and  $41^{\circ}\frac{1}{2}$  for a considerable time, sunk at once to  $77^{\circ}$ , not gradually or by jumps, but suddenly, as a weight falleth. The great descent of the quicksilver in the index thermometer (A) to  $440^{\circ}$  in the first freezing mixture I impute to the coldness of the weather, but was surpris'd to find it did not sink more than  $10^{\circ}$  lower in the second mixture; and in the third it did not reach so low as in the preceding, which, indeed, might be accounted for by the air growing warmer as the sun approached the meridian. At 10 h.  $6'\frac{1}{2}$  I poured some of the first mixture into the tumbler where the instruments were immersed in the second, but found it weakened it; I therefore mixed a fresh one at 10 h. 16'. It is however remarkable, that after pouring in the first mixture



on the second, the apparatus, which had risen a little before, sunk suddenly into the bulb. I have marked its progress as fast as I could catch it. Another extraordinary circumstance in this experiment is, that the mercurial thermometer (A) should not subside lower in the third than in the second mixture; whereas the spirit thermometer shewed an equal degree of cold, while the quicksilver in the apparatus thermometer was in the bulb. At 11 h. 21' I took the apparatus out to examine it, and, by shaking it in my hand, all of a sudden some of the quicksilver in the cylinder liquified; the concussion perhaps dissolved its solidity, for it was not above a minute out of the mixture. Wondering much at this unexpected phenomenon, as the quicksilver in the thermometer did not rise, I put it into the mixture again immediately; but finding the inclosed thermometer shewed no alteration, my curiosity determined me to examine it again; therefore, about four minutes after, I took it out a second time, and found the surface of the quicksilver in the cylinder was liquified about one-eighth of the whole quantity, as near as I could guess; the rest formed a solid ball, including the bulb of the thermometer, which easily accounts for the quicksilver in that instrument remaining stationary. Wishing to observe the whole process, and the cold being too severe for the same persons to stand in the open air for so long a time, I desired one of my officers, with an assistant, to mark down the observations at the times I went to warm myself, but by no means to make any alterations in my absence; by this means the observations were continued regularly for near four hours.

At the end of the experiments the thermometers (B), (C), (D), and (G), stood as follows,  $18^{\circ}\frac{1}{2}$ ,  $15^{\circ}$ ,  $9^{\circ}\frac{1}{2}$ ,  $15$ , which shews the alteration in the temperature of the air from the beginning. The thermometers (A), (D), and (F), were used in the experiment.



Experiment V. made February 22, 1781.

Time per. Watch.	Thermom. below 0.	Appara- tus.	Spirit Thermom.	Remarks and Occurrences.
h. ' "	A.	G.	C.	
8 4 0	78	40	29 $\frac{1}{2}$	
8 9 0	89	40	29	Making the freezing mixture.
8 11 0	—	—	—	Put the instruments into the mixture.
8 11 10	70	40	31 $\frac{1}{2}$	
8 11 30	60	39 $\frac{1}{2}$	32	
8 11 50	54	39 $\frac{1}{2}$	32	
8 12 30	—	—	—	Added more snow.
8 13 0	50	41	33 $\frac{1}{2}$	
8 13 30	51	42	34	
8 14 0	51	72	34	
8 14 15	51	78	34	
8 14 32	51	78	34	
8 15 0	—	—	—	Added more snow.
8 15 20	52	78	35	
8 15 50	—	—	—	Added more snow.
8 16 10	52	79	35	The quicksilver in the cylinder fluid.
8 17 0	52	79	35	
8 20 0	52	79	35	
8 25 0	52	79	35	Made a fresh mixture.
8 30 0	52	79	35	{ Removed the instruments into the new mixture.
8 30 45	52	79	35	
8 31 30	52	79	35	The quicksilver in the cylinder still fluid.
8 32 30	52	79	35	Put in mercurial thermometer (B).
8 32 50	52	79	35	64
8 33 20	52	79	35	80
8 34 0	52	79	35	90
8 35 0	52	79	35	90
8 35 0	52	79	35	91
8 37 0	52	79	35	91
11 31 0	52	79	35	91
				The quicksilver in the cylinder solid frozen. Took out all the instruments.

*Remarks on the fifth experiment.*

I had not intended to make any more experiments of this kind, thinking those already made had fully determined the freez-



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ing point of quicksilver; but the arrival of a gentleman, who wished to see it, induced me to repeat it again. The weather was clear and serene, the wind about S.S.W., and the several thermometers stood as follows, A  $82^{\circ}$ , B  $66^{\circ}$ , D  $34^{\circ}$ , E  $34^{\circ}$ , F  $42^{\circ}$ , G  $42^{\circ}$ , H  $46^{\circ}$ , at seven o'clock in the morning; and at eight o'clock they were A  $78^{\circ}$ , B  $114^{\circ}$ , D  $29^{\circ}\frac{1}{2}$ , E  $29^{\circ}\frac{1}{2}$ , F  $29^{\circ}\frac{1}{2}$ , G  $40^{\circ}$ , H  $43^{\circ}$ ; yet it is remarkable, that quicksilver which was constantly exposed to the air in a saucer was not froze. I impute the final descent of the quicksilver in the thermometers to the great degree of the cold in the atmosphere as in the sixth experiment, for there the effect was similar. The most remarkable circumstance in this day's operation was the sudden descent of the quicksilver in the apparatus thermometer, and the length of time it continued at  $79^{\circ}$  before the quicksilver in the cylinder became solid. The freezing mixture retaining an equal degree of cold for so long a time (as appeared by the spirit thermometer), and the consequent stationary situation of all the instruments, I apprehend, proceeded from the continual cold in the circum-ambient air; for at one o'clock the thermometers were risen but very little, being as follows, A  $35^{\circ}$ , B  $32^{\circ}$ , D  $21^{\circ}$ , E  $22^{\circ}$ , F  $30^{\circ}$ , G  $30^{\circ}$ , H  $34^{\circ}$ , the wind blowing brisk from N.W.



Experiment VI. made January 11, 1782.

Time per Watch.	Standard spirit H.	Mercurial therm. C.	Spirit therm. D.	Remarks and Occurrences.
h. ' "				
8 15 0	42	50	27 $\frac{1}{2}$	The instruments just put into the freezing mixture.
8 15 50	43	70	33	
8 16 15	43	100	34	
8 16 45	44	120	34	
8 17 15	44	140	34	
8 17 30	44	150	34	
8 17 45	44	155	34	
8 18 30	45	170	34	
8 19 0	—	—	—	
8 20 20	44	170	34	The mixture did not cover the bulb of (H). Added more snow and spirit.
8 21 0	45	170	34	
8 22 15	46	170	33	
8 22 50	46	170	33 $\frac{1}{4}$	
8 23 30	46	170	33 $\frac{1}{4}$	
8 24 30	46	170	33 $\frac{1}{4}$	
8 25 10	46	171	33 $\frac{1}{2}$	
8 26 0	46	171	33 $\frac{1}{2}$	
8 27 10	46	172	33 $\frac{1}{2}$	
8 27 45	46	172	33 $\frac{1}{2}$	Added more snow.  Made a fresh mixture. Put the instruments into a fresh mixture.
8 29 30	46	172	33 $\frac{1}{2}$	
8 30 30	46	172	33 $\frac{1}{2}$	
8 35 0	46	172	33 $\frac{1}{2}$	
8 36 0	46	173	34 $\frac{1}{2}$	
8 36 30	46	173	34 $\frac{1}{2}$	
8 37 0	46	173	34 $\frac{1}{2}$	
8 37 30	46 $\frac{1}{2}$	173	34 $\frac{1}{2}$	
8 38 30	47	174	35	
8 39 40	47	174	35	
8 40 30	47 $\frac{1}{2}$	174	35	
8 41 15	48	174	35	
8 42 0	48	175	35	
8 43 0	48	175	35	
8 44 0	48	175	35	
8 45 0	48	175	35	
8 45 15	47 $\frac{1}{2}$	175	35	
8 46 0	47 $\frac{1}{2}$	175	35	
8 46 30	47 $\frac{1}{2}$	175	35	



## Experiment VI. made January 11, 1782.

Time per Watch.			Standard spirit H.	Mercurial therm. C.	Spirit therm. C.	Mercurial th. A. and B.	Remarks and Occurrences.	Mer. ther. A in air.
h.	'	"				A.		
8	47	30	47 $\frac{1}{2}$	174	34 $\frac{1}{2}$		Put mercurial th. (A) into the mixture.	
8	48	0	47 $\frac{1}{2}$	174	34 $\frac{1}{2}$	45		
8	50	0	47 $\frac{1}{2}$	174	35	76		
8	50	30	47 $\frac{1}{2}$	174	35	114		
8	50	45	47 $\frac{1}{2}$	174	35	124		
8	51	0	47 $\frac{1}{2}$	174	35	146		
8	51	30	47 $\frac{1}{2}$	174	35	147		
8	52	30	47 $\frac{1}{2}$	174	35	147		
8	53	30	47 $\frac{1}{2}$	174	35	147 $\frac{1}{2}$		
8	54	0	47 $\frac{1}{2}$	174	35	147 $\frac{1}{2}$		
8	55	0	47 $\frac{1}{2}$	174	35	147 $\frac{1}{2}$		
8	56	0	47 $\frac{1}{2}$	174	35	147 $\frac{1}{2}$		
8	56	30	47 $\frac{1}{2}$	174	35	147 $\frac{1}{2}$		
8	57	35	47 $\frac{1}{2}$	175	35	148		
8	58	0	48	175	35	148		
8	59	0	48	175	35	148		
9	0	0	48	175	35	148		
9	1	0	48	175	35	148		
9	2	0	48	175	35	148		
9	3	0	48	175	35	148		
9	4	0	48	175	35	148		
9	5	0	48	175	35	148	Took out thermometer (A).	148
						B.		
9	8	0	48	174	35	70	Put in mercurial thermometer (B).	148
9	9	45	48	174	35	84		148
9	10	15	48	174	35	86		148
9	11	0	48	174	35	86	Added more snpw.	148
9	13	0	48	173	35	86		148
9	15	0	47	173	34 $\frac{3}{4}$	86		148
9	16	0	47	173	34 $\frac{1}{2}$	86		148
9	17	0	46 $\frac{1}{2}$	173	34 $\frac{1}{2}$	86		148
9	18	0	46 $\frac{1}{2}$	173	34 $\frac{1}{4}$	86		148
9	19	30	47	174	34	86		148
9	20	30	47	174	34	86		147
9	22	30	47	174	34	86		147
9	23	30	47	173	34	86		146
9	24	30	47	173	34 $\frac{1}{4}$	86		145 $\frac{1}{2}$



Experiment VI. made January 11, 1782.

Time per watch.	Standard spirit H.	Mercurial therm. C.	Spirit therm. D.	Mercurial therm. B.	Remarks and Occurrences.	Mer. ther. A in air.
h.						
9 25 30	47	173	34 $\frac{1}{2}$	86	Sunk instantaneously.	438
9 26 30	47	173	34 $\frac{1}{2}$	86		436
9 27 45	47	173	34 $\frac{1}{2}$	86		436
9 28 30	46	174	34 $\frac{1}{2}$	86		435
9 29 15	46	173	34 $\frac{1}{2}$	86		433
9 30 0	46	173	34 $\frac{1}{2}$	86		432 $\frac{1}{2}$
9 31 0	46	172	34 $\frac{1}{2}$	86		432
9 31 45	46	172	34 $\frac{1}{2}$	86		430
9 33 40	47	174	34 $\frac{1}{2}$	86		430
9 34 30	47	174	34 $\frac{1}{2}$	86	{ I suspect this variation to have been occasioned by different persons reading off the numbers. }	430
9 35 30	47	173	34 $\frac{1}{2}$	86		428
9 36 0	47	173	34 $\frac{1}{2}$	86		426
9 37 0	47	173	34 $\frac{1}{2}$	86		426
9 38 0	47	173	34 $\frac{1}{2}$	86		426
9 39 0	47	173	34 $\frac{1}{2}$	86		425
9 40 0	47	173	34 $\frac{1}{2}$	86		424
9 41 0	47	173	34 $\frac{1}{2}$	86		424
9 42 0	47	173	34 $\frac{1}{2}$	86		423
9 43 0	47	173	34 $\frac{1}{2}$	86		422
9 45 0	47	172	34	86	Put in apparatus (F) at $-40^{\circ}$ .	420
9 48 0	47	172	34	86		412
9 49 0	47	172	34	86	Took out apparatus (F) solid $-40^{\circ}$ .	412
9 50 0	47	172	34	86		412
9 51 0	47	172	34	86	Put in apparatus (G) fell directly to $-210^{\circ}$ .	410
2 53 0	47	172	34	86		405
9 55 0	47	172	34	86	Took out ditto, solid at $210^{\circ}$ .	402
9 56 0	47	172	34	86		401
9 57 0	47	172	34 $\frac{1}{2}$	86		400
9 58 0	47	172	34 $\frac{1}{2}$	86		398
9 59 0	47	172	34 $\frac{1}{2}$	86		396
10 0 0	47	172	34 $\frac{1}{2}$	86		394
10 1 0	47	172	34 $\frac{1}{2}$	86		392
10 2 0	47	172	34 $\frac{1}{2}$	86		390
10 3 0	47	172	34 $\frac{1}{2}$	86		388
10 4 0	47	172	34 $\frac{1}{2}$	86		386



## Experiment VI. made January 11, 1782.

Time <i>per</i> Watch.		Standard spirit H.	Mercurial therm. C.	Spirit therm. D.	Mercurial therm. B.	Remarks and Occurrences.	Mercurial B in air.
h.	"						
10	5	0	47	172	34	86	384
10	6	0	47	172	34	86	382
10	9	0	47	172	34	86	372
10	10	0	47	172	34	86	370
10	11	0	47	172	34	86	366
10	13	0	47	172	34	86	362
10	14	0	47	172	34	86	360
10	15	0	47	172	34	86	358
10	16	0	47	172	34	86	356
10	17	0	47	172	34	86	353
10	18	0	47	172	34	86	351
10	19	0	47	172	34	86	348
10	20	0	47	172	33 $\frac{1}{2}$	86	346
10	21	0	47	172	33 $\frac{1}{2}$	86	342
10	22	0	47	172	33 $\frac{1}{2}$	86	340
10	23	0	47	172	33 $\frac{1}{2}$	86	338
10	24	0	47	171	33 $\frac{1}{2}$	86	334
10	25	0	47	171	33 $\frac{1}{2}$	86	332
10	26	0	47	171	33 $\frac{1}{2}$	86	330
10	27	0	47	171	34	86	328
10	28	0	47	171	34	86	324
10	29	0	47	171	34	86	320
10	30	0	47	171	34	86	316
10	31	0	47	171	34	86	314
10	32	0	47	171	34	86	300
10	32	30	47	171	34	86	298
10	33	0	47	171	34	86	280
10	33	30	47	171	34	86	274
10	34	0	46	171	34	86	272
10	35	0	46	171	34	86	268
10	36	0	46	171	34	86	264
10	37	0	46	171	34	86	262
10	38	0	46	171	34	86	260
10	39	0	46	171	34	86	258
10	40	0	46	171	33 $\frac{1}{2}$	86	254
10	41	0	46	171	33	86	246

{ Apparatus (G) in the bulb, in open  
air, since 9 h. 53'.



Experiment VI. made January 11, 1782.

Time per Watch.	Standard spirit H.	Mercurial therm. C.	Spirit therm. D.	Mercurial therm. B.	Remarks and Occurrences.	A in air. Mer. ther.
h. / "						
10 42 0	46	171	32 $\frac{1}{2}$	86		244
10 43 0	46	170	32 $\frac{1}{2}$	86		238
10 44 0	46	170	32 $\frac{1}{2}$	86		234
10 45 0	46	170	32 $\frac{1}{2}$	86		230
10 46 0	46	170	32 $\frac{1}{4}$	86		228
10 47 0	46	170	32 $\frac{1}{4}$	86	{ External part of quicksilver in the apparatus (F) fluid, the center a globular fold. In the open air an hour. }	224
10 49 0	46	170	32 $\frac{1}{4}$	86		214
10 50 0	46	170	32 $\frac{1}{4}$	86		213
10 51 0	46	170	32 $\frac{1}{4}$	86		208
10 52 0	46	170	32	86		206
10 53 0	46	170	32	86		200
10 54 0	45	170	32	86		196
10 55 0	45	170	32	86		192
10 56 0	45	170	32	86		190
10 57 0	45	170	32	86		186
10 58 0	45	170	31 $\frac{1}{2}$	86		176
10 59 0	45	170	31 $\frac{1}{2}$	86		166
11 0 0	45	170	31 $\frac{1}{2}$	86	{ A portion of quicksilver in apparatus (F) still frozen. }	160
11 5 0	44	170	31	85		134
11 6 0	44	170	31	85		128
11 7 0	44	170	31	85		126
11 8 0	44	170	31 $\frac{1}{2}$	86		124
11 9 0	44	170	31 $\frac{1}{2}$	86		116
11 10 0	44	170	31 $\frac{1}{2}$	86		116
11 11 0	44	170	31 $\frac{1}{2}$	86		110
11 12 0	44	170	31 $\frac{1}{2}$	86		100
11 13 0	44	170	31 $\frac{1}{2}$	86		96
11 14 0	44	170	31 $\frac{1}{2}$	86		92
11 15 0	44	170	31 $\frac{1}{2}$	86		84
11 16 0	44	170	31 $\frac{1}{2}$	86		82
11 17 0	44	170	31	85		78
11 18 0	44	170	30 $\frac{1}{2}$	85		68
11 19 0	44	166	30 $\frac{1}{4}$	85		60
11 20 0	44	167	30	85		54



Experiment VI. made January 11, 1782.

Time <i>per</i> Watch.		Standard Spirit H.	Mercurial therm. C.	Spirit therm. D.	Mercurial therm. B.	Remarks and observations.	Mer. ther. A in air.
h.	"						
11	22	0	43	167	30	85	48
11	23	0	43	167	30	85	44
11	25	0	43	167	30	85	42
11	26	0	43	167	30	85	40
11	27	0	43	167	30	85	40
11	28	0	43	167	30	85	40
11	29	0	43	167	30	85	40
11	30	0	43	167	30	85	40
11	31	0	43	167	30	85	40
11	32	0	43	167	30	85	38
11	33	0	43	167	29 $\frac{1}{2}$	85	36
11	34	0	43	167	29 $\frac{1}{2}$	85	36
11	35	0	43	167	29 $\frac{1}{2}$	85	36
11	36	0	43	167	29 $\frac{1}{2}$	85	36
11	37	0	43	167	29 $\frac{1}{2}$	85	36
11	38	0	43	167	29 $\frac{1}{2}$	85	36
11	39	0	43	167	29 $\frac{1}{2}$	85	36
11	40	0	43	167	29 $\frac{1}{2}$	85	36
11	42	0	43	167	29 $\frac{1}{2}$	85	36
11	44	0	43	167	29 $\frac{1}{2}$	85	36
11	46	0	43	167	29 $\frac{1}{2}$	85	34
11	48	0	42 $\frac{1}{2}$	166	29	85	34
11	49	0	42	165	28 $\frac{1}{2}$	434 { The quicksilver in thermometer (B) sunk in an instant.	34
11	51	0	42	165	28 $\frac{1}{2}$	432	34
11	52	0	42	165	28 $\frac{1}{2}$	432	34
11	53	0	42	165	28 $\frac{1}{2}$	432	34
11	53	30	42	165	28	430	34
11	54	0	42	166	28	427	34
11	55	0	42	315	28	425 { The quicksilver in thermometer (C) subsided all at once.	
11	56	0	41	360	28	422	
11	57	0	41	360	28	420	
11	58	0	40 $\frac{1}{2}$	358	28	417	
11	58	30	40 $\frac{1}{2}$	355	27 $\frac{1}{2}$	415	
11	59	0	40	352	27 $\frac{1}{2}$	413	



Experiment VI. made January 11, 1782.

Time per Watch.			Standard spirit H.	Mercurial therm. C.	Spirit therm. D.	Mercurial therm. B.	Remarks and Occurrences.
h.	'	"					
12	0	0	40	350	27 $\frac{1}{4}$	408	Made a fresh mixture. Put the instruments into the fresh mixture.
12	1	0	40	345	27 $\frac{1}{4}$	404	
12	2	0	40	336	27	398	
12	3	0	40	330	27	394	
12	4	0	40	323	27	390	
12	5	0	40	315	27	384	
12	6	0	40	309	27	379	
12	7	0	40	300	27	374	
12	8	0	40	294	27	368	
12	9	0	40	285	27	362	
12	10	0	40	275	27	355	
12	12	0	40	257	27	343	
12	13	0	40	245	27	335	
12	14	0	40	235	26 $\frac{1}{2}$	329	
12	15	0	40	222	26 $\frac{1}{2}$	320	
12	16	0	—	—	—	—	
12	16	30	40 $\frac{1}{2}$	270	33	340	
12	17	0	42	335	33	340	
12	17	30	42	365	33	340	
12	18	0	42	370	33 $\frac{1}{2}$	340	
12	18	30	42	372	33 $\frac{1}{2}$	340	
12	19	0	42 $\frac{1}{2}$	372	33 $\frac{1}{2}$	340	
12	20	0	43	372	33 $\frac{1}{2}$	340	
12	21	0	43	372	33 $\frac{1}{2}$	340	
12	22	0	43	372	33 $\frac{1}{2}$	340	
12	24	0	43	374	33 $\frac{1}{2}$	340	
12	26	0	43	374	33	340	
12	28	0	43	374	33	340	
12	32	0	43	374	33	340	
12	37	0	43	374	33	340	
12	42	0	43	374	32	340	
12	45	0	43	374	32	340	
12	54	0	43	374	32	340	
12	59	0	43	374	32	340	
1	0	0	43	374	32	340	



## Experiment VI. made January 11, 1782:

Time per Watch.			Standard Spirit H.	Mercurial therm. C.	Spirit therm. D.	Mercurial therm. B.	Remarks and Occurrences.
h.	'	"					
1	5	0	42	373	30	340	
1	10	0	42	371	29	340	
1	14	0	41 $\frac{1}{2}$	370	29	340	
1	19	0	41	370	28 $\frac{1}{2}$	340	
1	21	0	41	370	29	340	
1	23	0	41	370	29	340	
1	26	0	41	370	28 $\frac{1}{2}$	340	
1	30	0	40 $\frac{1}{2}$	370	28	340	
1	35	0	40	370	28	340	
1	40	0	40	370	28	340	
1	45	0	40	360	27	340	
1	46	30	40	—	27	400	
1	46	45	40	—	27	410	
1	47	0	40	—	27	438	
1	49	0	39	335	26 $\frac{1}{2}$	433	
1	50	0	39	322	26	428	
1	51	0	38	312	26	423	
1	54	0	38	291	26 $\frac{1}{2}$	413	
1	55	0	38	280	26 $\frac{1}{2}$	408	
1	56	0	38	273	26 $\frac{1}{2}$	403	
1	57	0	38	266	26 $\frac{1}{2}$	398	
1	58	0	38	259	26 $\frac{1}{2}$	394	
1	59	0	38	253	26 $\frac{1}{2}$	388	
2	0	0	38	241	26 $\frac{1}{2}$	382	
2	1	0	38	232	26 $\frac{1}{2}$	376	
2	2	0	38	225	26 $\frac{1}{2}$	371	
2	3	0	38	212	26 $\frac{1}{2}$	363	
2	4	0	38	202	26 $\frac{1}{2}$	357	
2	5	0	38	193	26 $\frac{1}{2}$	350	
2	6	0	37 $\frac{1}{2}$	180	26 $\frac{1}{2}$	341	
2	7	0	37 $\frac{1}{2}$	167	26 $\frac{1}{2}$	332	
2	8	0	37 $\frac{1}{2}$	158	26	328	
2	9	0	38	145	26	320	
2	10	0	38	132	26	310	
2	11	0	38	123	26	304	
2	12	0	38	105	26	300	

Added snow, the mixture growing thin.



Experiment VI. made January 11, 1782.

Time per Watch.	Standard spirit H.	therm. C. Mercurial	Spirit therm. D.	Mercurial therm. B.	Remarks and Occurrences.
h. ' "					
2 13 0	38	80	26	282	
2 14 0	38	55	26	276	
2 15 0	38	37	26	270	
2 16 0	38	45	26	262	
2 17 0	38	35	26	252	
2 18 0	38	35	26	250	
2 19 0	37½	34	26	244	Took out all the instruments.

This singular experiment, though it did not answer the intention for which it was principally designed, yet afforded many striking phænomena which I shall mention in the course of these remarks. After a cold night, the quicksilver in the thermometer was at 44° below 0 at seven o'clock in the morning: thinking this great degree of cold was the most favourable opportunity of observing how low it was possible to make the quicksilver descend in the tube of the thermometers, I resolved to embrace it, and at the same time to observe the concurrent degrees with a spirit thermometer; but as those sent out to me in 1781 (D and E) differed so much from the thermometers of quicksilver, I resolved to make use of another spirit thermometer made by NAIRNE and BLOUNT, and which was also furnished me by the Royal Society in 1774. With this instrument, which I call the standard, and marked with the letter H, I have made observations eight years, and found it agree very well with others made of quicksilver; and the more readily to discover the variation of (D), I employed it also in the same experiment; but before I began the following observations



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were taken, the instruments all exposed to the open air, where they are continually kept. The thermometers are marked from (A) to (H), and the observations are regularly in that order.

h. ,	A	B	C	D	E	F	G	H
7 45	44½	45	41	28	29	40	40	46
7 50	46	64	124	30	32	42	41	46
7 55	—	—	60	—	—	—	—	—
7 57	44	—	—	—	—	—	—	—

It is observable, that neither the quicksilver which was in the cylinders affixed to (F) and (G), nor the other quicksilver which I constantly kept in the same place, some in a saucer, some in a gallipot, and some in a phial, shewed the least appearance of congelation. Being engaged in preparing for the ensuing experiment, I did not remark either the great descent or ascent of the quicksilver in (C), which must have been very sudden, as my remarks are only five minutes asunder.

It may be necessary to mention, that the thermometer (H) was mounted on a scale the whole length (as usual for meteorological observations), and (C) was armed with elastic gum from the bulb to about half or three-quarters of an inch above the surface of the freezing mixture.

The small descent of the quicksilver in (C), and the little effect produced by moving it into a second mixture, made me at first apprehend the instrument was damaged; I did not, however, take it out, but took another thermometer (A), and put it also in the mixture; but I find it was stationary at a higher degree than (C): I therefore exchanged (A) for the mercurial thermometer (B), which to my great surprize was stationary at 86°, nor could it be got lower until the cold of the mixture diminishing it fell

at



at once to  $434^{\circ}$ , and a few minutes afterwards (C) fell to  $360^{\circ}$ . Imagining that a new mixture would now bring it very low, I made another, but in the mean time the instruments had risen greatly, and after standing in the fresh mixture (C) sunk to  $374^{\circ}$ , and (B) to  $438^{\circ}$ . I should have mentioned, that these mixtures were double in quantity to those used in the former experiments; instead of glass tumblers, they were made in pint basons.

I observed also, that the mixtures seemed to grow thin sooner than common; for I always made them of the consistence of pap. I added snow at times, to thicken it, but found it had very little effect, but rather decreased the cold. It is with great diffidence I offer it as my opinion, that the temperature of the air was too cold, and that the quicksilver being nearly in a state of congelation before plunged into the mixture, was instantly frozen on putting the instruments into them; and as the quicksilver in the tubes must have been of the same temperature with that in the bulbs of the thermometers before the experiment, I should imagine, that when the quicksilver in the bulb was frozen solid, it communicated an addition of cold to that in the tube, and froze it also, which prevented its subsiding as usual; for in other cases, the contraction of the quicksilver, when solid in the bulb, was the cause of the quicksilver subsiding in the tube; but then the latter was fluid, for the circumambient air was warmer than the degree at which quicksilver freezes, and the increased cold was applied only to the bulb. The observations made before the experiment began, as related in the beginning of these remarks, shew the quicksilver in the thermometer was congealing, and that (A) and (C) were actually frozen.

When



When I removed the thermometer (A) out of the mixture at 9 h. 5', I hung it up in the air, and have noted down, in a separate column on the right-hand side of the page, its appearances corresponding to the times put down on the other side of the page. It is remarkable, that (A) and (C) have each an air-bubble blown at the top; but the thermometer (B) had none.

Whilst the instruments were stationary in the foregoing experiment, I put the apparatus (F) and (G) severally into the mixture with the others; the consequence was, that in two minutes the quicksilver in the cylinder was frozen solid; but as there was a difference in the effect I shall be more particular. At 9 h. 48' put in apparatus (F), when it stood in the air at  $40^{\circ}$  or  $41^{\circ}$  below 0; and at 9 h. 50' took it out frozen solid, and the inclosed thermometer pointing still at  $40^{\circ}$  or  $41^{\circ}$ . I then hung it up in the open air, and looked at it only now and then. At 10 h. 47' (after being exposed to the air near an hour), I found only a small quantity of the surface of the quicksilver was fluid, the rest was a frozen globe resembling a ball of polished silver; the thermometer inclosed was still at  $40^{\circ}$ . At 11 h. 4' I observed a segment of a globe of solid quicksilver; in the inside was a concavity made, I supposed, by the bulb of the thermometer. The thermometer was still at  $40^{\circ}$ , which undoubtedly is the freezing point of quicksilver, as in this instance part of it was frozen, and part solid. I withdrew the thermometer, poured out the fluid quicksilver, and returned the thermometer into the cylinder, shortly after which it was at  $37^{\circ}$ , and the frozen segment was then fluid.

The apparatus (G) was hanging in the open air at  $40^{\circ}$ , and put into the same freezing mixture at 9 h. 51', on which it sunk instantly to  $210^{\circ}$ , at which degree it was stationary at  
9 h.



9 h. 53', when it was taken out of the mixture perfectly solid. At 10 h. 6' I saw it had subsided into the bulb (I mean the quicksilver in the inclosed thermometer) which was the last time I particularly noticed it. It may be necessary to mention, that finding the quicksilver in the enclosed thermometer sink instantaneously as soon as the apparatus was put into the freezing mixture, I took it out immediately, to view it, and replaced it in a few seconds of time. I found the quicksilver was not yet solid, but was in frozen pieces of irregular shapes, resembling ice that had been broken to pieces by concussion in a pail of water, but with this remarkable difference, that as ice swims on the water, the frozen quicksilver subsided in fluid quicksilver, and the segment of ice, mentioned a little before to be found in the thermometer (F) was also at the bottom of the cylinder, and remained there after decanting the liquid quicksilver from it. Hence we may conclude, that cold increases the gravity of quicksilver, as indeed must be the case, since it is certain it occupies less space in a solid than in a fluid state.



## Experiment VII. made January 22, 1782.

Time per Watch.	Standard Spirit H.	Mercurial therm. C.	Spirit therm. D.	Remarks and Occurrences.
h. ' "				
8 42 0	—	—	—	Making the fresh mixture.
8 45 0	—	—	—	Put in the instruments.
8 45 30	38	65	31½	
8 46 0	41	105	33	
8 46 15	42	130	33	
8 46 30	43	155	33½	
8 46 45	44	183	33½	
8 47 15	44	207	33½	
8 47 45	44	235	34	
8 48 0	44½	235	34	
8 48 30	45	235	34	
8 49 0	45	235	34	
8 50 0	45	235	34	
8 51 0	45	235	34	
8 52 0	46	237	34	
8 53 0	46	238	34	
8 54 0	46	238	34	
8 55 0	46	238	34	
8 56 0	46	237	34	
8 57 0	46	237	34	
8 58 0	46	236	34	
9 0 0	46	236	34	Making a fresh mixture.
9 4 0	45½	236	33	
9 5 0	—	—	—	Removed the instruments into the new mixture.
9 5 15	44	235	32	
9 5 45	44	237	32	
9 6 0	44½	237	31	
9 8 0	—	—	—	Put in apparatus (G).
9 9 0	—	—	—	{ (G) sunk into the bulb, quicksilver in the cylinder fluid.
9 11 0	44½	237	30½	
9 13 0	44½	237	29½	
9 15 0	44½	237	29½	
9 16 0	44½	237	29½	
9 17 0	44	237	29½	
9 18 0	44	237	29½	
9 19 0	43½	237	29½	



Experiment VII. made January 22, 1782.

Time <i>per</i> Watch.		Standard spirit H.	Mercurial therm. C.	Spirit therm. D.	Remarks and Occurrences.
h.	"				
9 20	0	43 $\frac{1}{2}$	237	29 $\frac{1}{2}$	Examined (G) remains as the last time.
9 21	0	43 $\frac{1}{2}$	237	29	
9 22	0	33	236	29	
9 23	0	42 $\frac{1}{2}$	236	29	
9 24	0	42 $\frac{1}{2}$	235	29	
9 25	0	42 $\frac{1}{2}$	235	29	
9 26	0	42 $\frac{1}{2}$	235	29	
9 27	0	42	235	29	
9 28	0	42	234 $\frac{1}{2}$	29	
9 29	0	42	234	29	
9 30	0	42	234	29	(G) remains still the same.
9 31	0	41 $\frac{1}{2}$	234	29	
9 32	0	41	234	29	
9 33	0	41	234	29	
9 34	0	41	234	28 $\frac{1}{2}$	
9 35	0	41	234	28 $\frac{1}{2}$	
9 36	0	41	234	28 $\frac{1}{2}$	
9 37	0	40 $\frac{1}{2}$	234	28 $\frac{1}{2}$	
9 38	0	40 $\frac{1}{2}$	234	28	
9 39	0	40 $\frac{1}{2}$	234	27 $\frac{1}{2}$	
9 40	0	40	234	27	(G) remains in the bulb, quick. in the cylinder fluid.
9 41	0	40	234	27	
9 42	0	40	234	26 $\frac{1}{2}$	
9 43	0	40	233	26 $\frac{1}{2}$	
9 44	0	40	232	26 $\frac{1}{2}$	
9 45	0	40	232	26 $\frac{1}{2}$	
9 46	0	39 $\frac{1}{2}$	232	26 $\frac{1}{2}$	
9 47	0	39 $\frac{1}{2}$	232	26 $\frac{1}{2}$	
9 48	0	39	232	26	
9 49	0	39	231 $\frac{1}{2}$	26	
9 50	0	39	231 $\frac{1}{2}$	26	
9 50	30	39 $\frac{1}{2}$	231	26	
9 51	0	39	232	26	
9 52	0	39	650	26	
9 52	20	—	850	—	
9 52	30	—	1050	—	
9 52	40	—	1120	—	



## Experiment VII. made January 22, 1782.

Time <i>per</i> Watch.	Standard spirit H.	Mercurial therm. C.	Spirit therm. D.	Remarks and Occurrences.
h. ' "				
9 52 50	—	1300	—	
9 53 0	—	1350	—	
9 53 10	—	1360	—	
9 53 30	38	1361	26	
9 54 0	38	1361	26	Apparatus (G) as before; took it out entirely.
9 56 0	38	1362	25 $\frac{1}{2}$	
9 57 0	38	1362	25 $\frac{1}{2}$	Made a fresh mixture.
9 58 30	38	1305	31	Put the instruments into the new mixture.
9 59 30	39	1305	32	
10 0 0	40	1305	32	
10 0 30	40	1305	32	
10 1 0	40	1306	32	
10 2 0	40	1306	32	
10 3 0	40	1306	32	
10 4 0	40	1307	32	
10 5 0	40	1306	32	
10 6 0	40	1306	31 $\frac{1}{2}$	
10 7 0	40	1306	31 $\frac{1}{2}$	
10 8 0	40	1306	31 $\frac{1}{2}$	
10 9 0	40	1307	31	
10 10 0	40	1307	31	
10 11 0	40	1307	31	
10 12 0	39 $\frac{1}{2}$	1307	30 $\frac{1}{2}$	
10 13 0	39 $\frac{1}{2}$	1307	30 $\frac{1}{2}$	
10 14 0	39	1306	30	
0 15 0	39	1306	30	Found (C) has lost its bulb in the former mixture.

*Remarks on the seventh experiment.*

From the sixth experiment I was induced to think, that the nearer the temperature of the atmosphere approached to the freezing point of quicksilver, so that a great degree of cold might be communicated to the bulb of a thermometer and yet the quicksilver in the tube remain fluid, would be the properest



perest time for ascertaining in this manner to what degree quicksilver will contract by the application of cold. With this view this seventh experiment was made: the several thermometers from A to H were as follows, before I began, A 38, B 36, C 33, D 24, E  $24\frac{1}{2}$ , F 33, G 33, H 37. Those used in the experiment were C, D and H. The first was to shew the descent of the quicksilver; and the two last, which were spirit thermometers, were employed to shew the corresponding contractions of the two substances, quicksilver and alcohol. After above an hour's attendance on them, I was highly pleased to see the quicksilver fall to  $1367^{\circ}$  below the cypher, especially as I supposed, by changing the mixture for a fresh one, I should get it much lower still. I made another accordingly, and removed the instruments into it. The quicksilver rose, as was common in changing the mixtures; but after waiting a considerable time, without its descending again, I recollected Professor BRAUN mentioning that his thermometers were always broken when below  $600^{\circ}$ . This made me examine mine, and I found the bulb was broken and fallen off; and on a diligent search in the mixture, I could not find either quicksilver or the pieces of glass; I therefore conclude it had dropped off into the other mixture, which unluckily I had thrown away the moment before, having occasion to use the basin in decanting the present mixture: I have no doubt but it broke at the time the quicksilver fell so rapidly. During the course of this experiment I put the apparatus (G) into the freezing mixture; in a minute's time the quicksilver in the inclosed thermometer had subsided into the bulb, and remained so during the time it continued immersed in the freezing mixture, which was about three quarters of an hour; but though the thermometer, which made part of the apparatus, shewed so great a degree of cold,



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yet the quicksilver in the cylinder was never frozen ; and indeed the spirit thermometers, suspended in the mixture, seemed to indicate, that there was not sufficient cold to freeze quicksilver, except at the beginning ; for I observe, it is not effected at 40°, without continuing some time at that degree, as appears very clearly from the third experiment.

Experiment VIII. made December 21, 1781.

Time per Watch.	Mercurial thermom.	Apparatus.	Spirit Thermom.	Remarks and Occurrences.
h. , "				
10 10 0	—	—	—	Made the freezing mixture.
10 12 0	—	—	—	Put in the gallipot of quicksilver.
10 13 0	—	—	—	Put thermometer (B) into the quicksilver.
10 13 30	—	35	—	
10 13 35	—	36	—	
10 13 40	—	37	—	
10 14 0	—	37	—	Put thermometer (A) into the freezing mixture.
10 14 30	30	38	—	
10 14 40	40	38	—	
10 15 0	42	38	—	
10 15 15	43	39	—	
10 15 30	44	39	—	
10 16 0	48	39	—	
10 16 15	56	39	—	
10 16 30	64	39	—	
10 16 45	70	39	—	
10 17 0	76	39	—	
10 17 15	81	39	—	
10 17 30	87	39	—	
10 17 45	92	39	—	
10 18 0	97	39	—	
10 18 15	102	39	—	
10 18 30	108	39	—	
10 18 45	113	39	—	
10 19 0	118	39	—	
10 19 15	122	39	—	
10 19 30	126	39	—	
10 19 45	130	39	—	

Experiment



Experiment VIII. made December 21, 1781.

Time <i>per</i> Watch.			Mercurial thermom.	Appa- rus.	Spirit thermom.	Remarks and Occurrences.
h.	'	"				
10	20	0	136	39	—	
10	20	15	139	39	—	
10	20	30	143	39	—	
10	20	45	147	39	—	
10	21	0	151	39	—	
10	21	15	154	39	—	
10	21	30	159	39	—	
10	21	45	163	39	—	
10	22	0	166	39	—	
10	22	15	169	39	—	
10	22	30	173	39	—	
10	22	45	175	39	—	
10	23	0	178	39	—	
10	23	15	182	39	—	
10	23	30	185	39	—	
10	23	45	187	39	—	
10	24	0	189	39	—	
10	24	15	192	39	—	
10	24	45	197	39	—	
10	25	0	199	39	—	
10	25	15	201	39	—	
10	25	45	188	39	—	{ Thermometer (A) slipped into the gallipot containing the quicksilver, by accident; replaced it.
10	27	15	200	39	—	
10	30	45	127	39	—	
10	31	0	122	39	—	
10	32	0	—	—	—	Put a spirit thermometer into the mixture.
10	32	30	96	39	27	
10	33	0	86	39	27	
10	33	30	80	39	27 $\frac{1}{2}$	
10	33	45	72	40	27 $\frac{1}{2}$	
10	34	30	58	40	27	Made another mixture.
10	38	45	38	40	27	Took out the instruments.
10	40	0	—	—	—	Changed the mixture.
10	40	30	59	41	—	
10	40	45	63	41	—	
10	41	0	67	41 $\frac{1}{2}$	—	



## Experiment VIII. made December 21, 1781.

Time per Watch.			Mercurial thermom.	Apparatus.	Spirit thermom.	Remarks and Occurrences.
h.	'	"				
10	41	10	70	41 $\frac{1}{2}$	—	Put in the spirit thermometer.
10	41	30	78	41 $\frac{1}{2}$	29	
10	42	0	84	41 $\frac{1}{2}$	30 $\frac{1}{2}$	
10	42	15	88	41 $\frac{1}{2}$	31	
10	42	30	91	41 $\frac{1}{2}$	31	
10	43	0	95	41	31	
10	43	15	99	41	31	
10	43	30	100	41	31	
10	43	45	101	41	31	
10	44	0	101	41	31	
10	44	30	101	41	31	
10	45	15	101	40 $\frac{1}{2}$	31	
10	46	0	101	40	30 $\frac{3}{4}$	
10	47	0	101	40	30 $\frac{1}{2}$	
10	47	30	101	40	30 $\frac{1}{2}$	
10	48	0	101	40	30 $\frac{1}{4}$	
10	48	30	101	40	30	
10	49	0	101	40	30	
10	49	30	101	40	29 $\frac{3}{4}$	
10	50	0	101	40	29 $\frac{3}{4}$	
10	50	30	101	40	29 $\frac{1}{2}$	
10	51	0	101	39 $\frac{1}{2}$	29 $\frac{1}{2}$	The descent in the mercurial therm. was sudden.
10	51	30	101	39 $\frac{1}{2}$	29 $\frac{1}{4}$	
10	52	0	101	39 $\frac{1}{4}$	29	
10	52	30	101	39 $\frac{1}{4}$	29	
10	53	0	101	39	29	
10	54	0	113	39	29	
10	54	30	112	39	29	
10	54	45	111	39	28 $\frac{3}{4}$	
10	55	0	110	39	28 $\frac{3}{4}$	
10	55	30	108	39	28 $\frac{1}{2}$	
10	55	45	106	38 $\frac{3}{4}$	28 $\frac{1}{2}$	
10	56	0	104	38 $\frac{1}{2}$	28 $\frac{1}{4}$	
10	56	30	102	38 $\frac{1}{2}$	28 $\frac{1}{4}$	
10	57	0	99	38 $\frac{1}{2}$	28 $\frac{1}{4}$	
10	57	30	96	38 $\frac{1}{2}$	28	
10	58	0	93	38 $\frac{1}{4}$	27 $\frac{3}{4}$	



Experiment VIII. made December 21, 1781.

Time per watch.	Mercurial thermom.	Apparatus.	Spirit thermom.	Remarks and Occurrences.
h.				
10 58 30	89	38 $\frac{1}{4}$	27 $\frac{3}{4}$	Stirred the mixture.
10 59 0	85	38	27 $\frac{1}{2}$	
10 59 30	82	38	27 $\frac{1}{2}$	
11 0 0	78	38	27 $\frac{1}{2}$	
11 0 30	75	38	27 $\frac{1}{2}$	Stirred the mixture.
11 1 0	70	38	27 $\frac{1}{2}$	
11 1 30	66	38	27 $\frac{1}{4}$	
11 2 0	64	38	27 $\frac{1}{4}$	
11 2 30	60	38	27 $\frac{1}{4}$	
11 3 0	55	38	27 $\frac{1}{4}$	
11 3 30	51	37 $\frac{3}{4}$	27	
11 4 0	45	37 $\frac{1}{4}$	27	
11 4 30	44	37	27	

This eighth experiment was made with a view to try, whether quicksilver would freeze whilst in contact with the freezing mixture. For this purpose I did not use the apparatus employed in the other examples, but substituted another, by taking a gallipot made of flint stone (as being thinner than the common sort) of about an ounce measure, and filled it half full of quicksilver, into which I inserted the mercurial thermometer (B) and employed the other mercurial thermometer (A) as an index, as before. I hoped by this means to determine exactly when the quicksilver was congealed, as I had free access to it at all times, which was not the case when inclosed in the cylindrical glass, the worsted wound round the tube of the ivory thermometer to exclude the air, equally excluding any instrument from being introduced to touch the quicksilver. I made a kind of skewer, with a flat blunt point, of dried cedar wood



wood for lightness, which I found would remain in the gelatinous freezing mixture at any depth I chose; but when inserted into the quicksilver contained in the gallipot, the great disproportion of gravity made it rebound upwards, and by the touch I could easily perceive, by the resistance it met with, whether it proceeded from quicksilver in a fluid or congealed state. The event did not answer my wishes, for I could not find that the quicksilver was frozen in the least during the trial. Indeed the temperature of the air was not favourable, being under  $20^{\circ}$  below the cypher. The large quantity too of the quicksilver in the gallipot, as well as the thickness of that vessel, might both of them contribute to render the operation unsuccessful; yet, as the apparatus thermometer shewed the same degree ( $-40$ ) as when quicksilver froze in the glass cylinder, I am of opinion it would congeal by this simple method in very cold weather, and a long continued application of a proper degree of cold by the mixtures.

Experiment IX. made February 22, 1782.

Whilst I was attending on the preceding experiment (the 5th) and had removed the instruments into a second mixture, the former one by this means being unemployed, I put into it a gallipot (the same I used in the eighth experiment) with about three quarters of a pound of quicksilver, and let it remain immersed in the mixture a considerable time (I suppose near half an hour), and finding, by touching with a quill, that part of it was congealed, I drew the gallipot out, it being previously flung with a string, and decanted off the superincumbent mixture and fluid quicksilver; the remainder, about two-thirds of the whole quantity, remained solid in the gallipot;



pot; the internal surface remained every where very rough and white, shining like an old silver spoon long in use and having lost its polish. Part of it became fluid in a few minutes; and imagining it afforded a fine opportunity of confirming what had before appeared to be the freezing point of quicksilver, I put a mercurial thermometer (F) which then stood at  $34^{\circ}$ , into the part of the quicksilver in the gallipot, which was just thawed, and it subsided directly to  $-40^{\circ}$ , and became stationary. I repeated the same with another instrument, and the consequence was the same. I then tried the spirit thermometer (D) which became stationary at  $28^{\circ}\frac{1}{2}$ ; and another spirit thermometer (E) which I took out of the freezing mixture, where it was at  $35^{\circ}$ , and it rose to  $30^{\circ}$ ; and by comparing the spirit thermometers with mercurial ones, and also with another spirit thermometer (H) it appears, that  $29^{\circ}$  on the former is about equal to  $40^{\circ}$  on the scale of both the latter. By the time these observations were taken, the frozen lump was loosened in the gallipot: I turned it out, and beat it with an hammer; it yielded a dead sound and flattened, but its cohesion was very weak; for, instead of expanding into a thin plate, as in other instances when frozen in the bulb of a thermometer, it crumbled to pieces, and had not that polish, which I had before constantly observed. I attributed these circumstances to the effect of the spirit of nitre on the quicksilver. It thawed very soon after its parts were disjoined by the stroke of the hammer.



## Experiment X. made January 26, 1782.

*Quicksilver frozen by the natural cold in Hudson's Bay.*

The subject of this curious phænomenon was quicksilver put into a common two-ounce phial, and corked. The phial was about a third part full, and had been constantly standing by the thermometer for a month past. At eight o'clock this morning I observed it was frozen rather more than a quarter of an inch thick round the sides and bottom of the phial, the middle part continuing fluid. As this was a certain method to find the point of congelation, I introduced the mercurial thermometer (F) and the spirit thermometer (D) into the fluid part, after breaking off the top of the phial, and they rose directly and became stationary; the former at  $40^{\circ}$  or  $40^{\circ}\frac{1}{2}$ , the latter at  $29^{\circ}\frac{3}{4}$ , both below the cypher. Having taken these out, I put in two others, (G) and (E); the former became stationary at  $40^{\circ}$ , the latter at  $30^{\circ}$ . I then decanted the fluid quicksilver, to examine the internal surface of the frozen quicksilver, which proved very uneven, with many radii going across; some of these resembled pins with heads. Urgent business called me away an hour. On my return I found a small portion only had liquified in my absence. I then broke the phial entirely, and with a hammer repeatedly struck the quicksilver. It beat out flat, yielded a deadish sound, and became fluid in less than a minute afterwards. I should have mentioned, that I brought the thermometer (F) into a room, where it rose to  $55^{\circ}$  above the cypher, and then let it cool again in the open air, before I put it into the frozen quicksilver. My reason was, for fear the quicksilver in the thermometer should be frozen so as to render



the observation uncertain; but I did not observe it differed any thing of consequence from (G) which was not taken in, but put directly into the phial. By the comparative observations of the several thermometers it appears, that  $30^{\circ}$  on the scale of the spirit thermometers (D) and (E) is about equal to  $40^{\circ}$  or  $41^{\circ}$  on my standard spirit thermometer (H). The following was the state of the instruments that morning,

	A.	B.	D.	E.	F.	G.	H.
At eight	- 103	- 80	$33\frac{1}{2}$	33	$42\frac{1}{2}$	42	46
At nine	- 323	- 444	- 29	$- 29\frac{1}{2}$	- 40	- 40	- 44
At noon	34	32	21	$21\frac{1}{2}$	30	$29\frac{1}{2}$	34

It may be worth remarking, that the quicksilver in the thermometer (B) which had been very near  $500^{\circ}$ , and was then at  $444^{\circ}$ , very readily run up and down the tube by elevating either end of the instrument.



EXPLANATION OF PLATE VII.

Fig. 1. The thermometer seen in front.

A. The stem and bulb reaching below the scale.

B. B. Worsted wrapped round the stem, in order to keep it steady in the cylinder, and prevent the access of air.

Fig. 2. The cylinder, swelled at bottom, to hold the quick-silver to be frozen.

Fig. 3. A section of the whole apparatus when put together, shewing in what manner the thermometer is inserted and retained in the cylinder. This section is perpendicular to the scale of the thermometer.

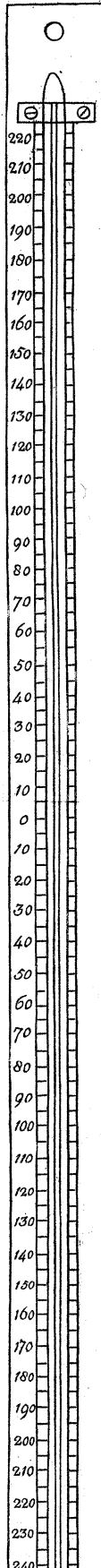




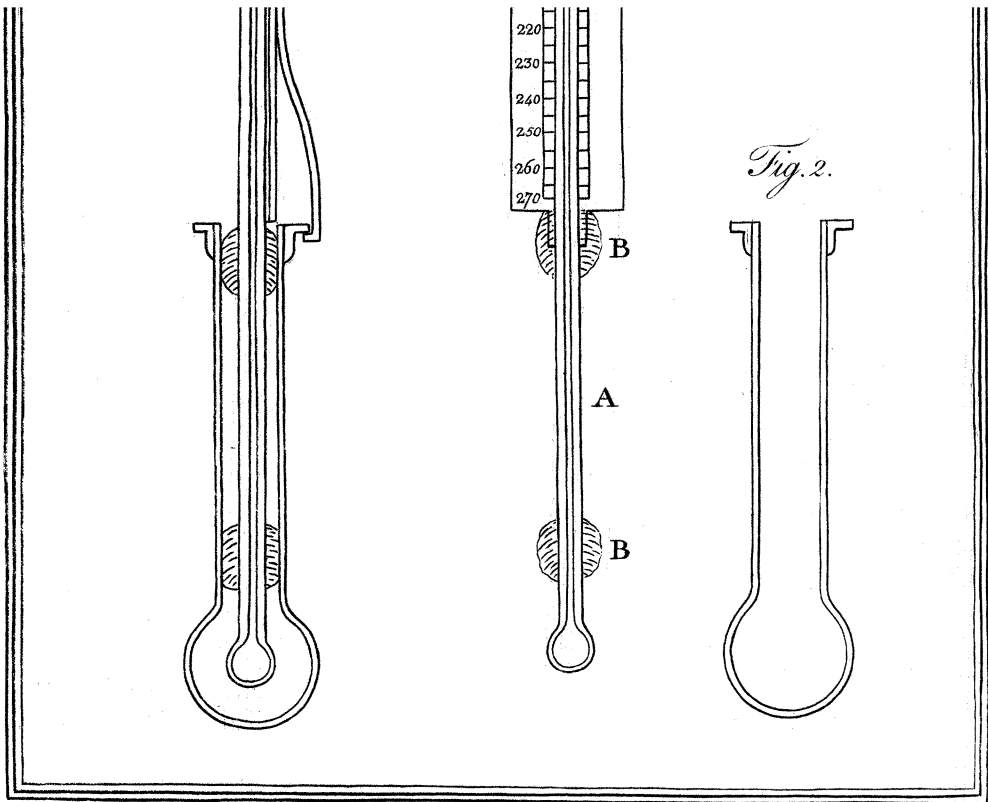
*Fig. 3.*



*Fig. 1.*





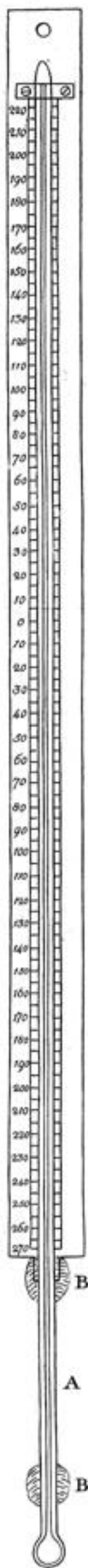




*Fig. 3.*



*Fig. 1.*



*Fig. 2.*

